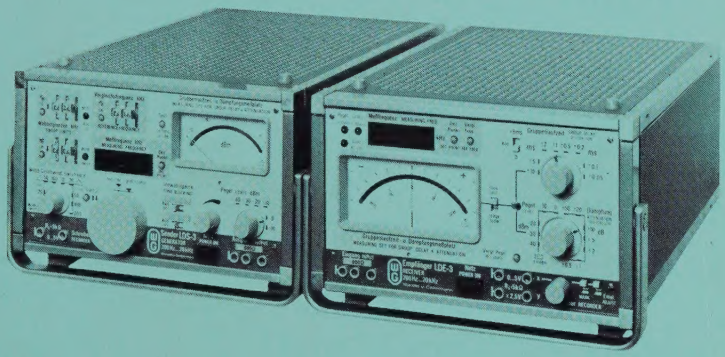
QA

File: W7

Description and
Operating Manual



FOR CAL Procedure see
WGR/1 Manual (~~7440~~
1559

Measuring Set for Group Delay and Attenuation LD-3

in the frequency range 200 Hz to 20 kHz

MEASURING SET FOR GROUP DELAY AND ATTENUATION LD-3

in the frequency range 200 Hz to 20 kHz

Description and Operating Manual 616/615 B

1.9.73 Loe
0.25.9.73 2075

Subject to change without notice

Wandel u. Goltermann · Reutlingen/Germany

CONTENTS

INTRODUCTION

1. TECHNICAL SPECIFICATIONS . . . . . p. 1-1

1.1. Complete Measuring Set . . . . . p. 1-1
1.2. Generator LDS-3 . . . . . p. 1-2
1.3. Receiver LDE-3 . . . . . p. 1-3
1.4. General specifications of the Measuring Set LD-3 . . . . . p. 1-6
1.5. Ancillary devices (if requested, available for purchase) . . . . p. 1-7
1.6. Order numbers . . . . . p. 1-8

2. OPERATION . . . . . p. 2-5

2.1. Operating controls . . . . . p. 2-5
2.1.1. Generator LDS-3 (Send Unit) . . . . . p. 2-5
2.1.2. Receiver LDE-3 (Receive Unit) . . . . . p. 2-7
2.1.3. Back panel of Generator LDS-3 (Send Unit) and Receiver LDE-3 (Receive Unit) . . . . . p. 2-9

2.2. Connections and setting-up instructions . . . . . p. 2-9
2.3. Operation of the Send Unit . . . . . p. 2-10
2.3.1. Level setting . . . . . p. 2-10
2.3.2. Frequency setting and readout. . . . . p. 2-10

2.4. Operation of the Receive Unit . . . . . p. 2-11
2.4.1. Input level range and monitoring input level . . . . p. 2-11
2.4.2. Frequency readout . . . . . p. 2-11
2.4.3. Measured result indication . . . . . p. 2-11
2.4.3.1. Group delay/frequency distortion $\Delta\tau g$ . . . p. 2-12
2.4.3.2. Attenuation/frequency distortion characteristic Δa . . . . . p. 2-12
2.4.3.3. Receive level . . . . . p. 2-12

2.5. Measuring . . . . . p. 2-13
2.5.1. Point-by-point measurements . . . . . p. 2-13
2.5.1.1. Test circuit . . . . . p. 2-15

2.5.2. Sweep measurements . . . . . p. 2-15
2.5.2.1. X-Y-plotter operation . . . . . p. 2-16

2.6. Retransmission of the measured results . . . . . p. 2-17

2.7. Additional possibilities for application . . . . . p. 2-19
2.7.1. Operated as Level Measuring Set and as Swept Frequency Measuring Set . . . . . p. 2-19
2.7.2. Receiver LDE-3 as a Frequency Counter . . . . . p. 2-19

2.8. Ancillary devices . . . . . p. 2-20
2.8.1. Speaker Facility LDZ-3 . . . . . p. 2-20
2.8.1.1. Step-by-step instructions for operation of the Speaker Facility LDZ-3 . . . . . p. 2-23

2.8.2. Low-pass filter . . . . . p. 2-23
2.8.3. Tone blocking . . . . . p. 2-24
2.8.4. D.C. loop holding circuit for measuring over subscriber's telephone circuit . . . . . p. 2-24
2.8.5. Crystal controlled time base . . . . . p. 2-25
2.8.6. Remote control of level, Measuring Frequency and Reference Frequency . . . . . p. 2-26

3. TECHNOLOGICAL INSTRUCTIONS . . . . . p. 3-1

3.1. Explanation and expanded presentation for the technical specifications of para. 1.1.2. . . . . p. 3-1
3.1.1. Additional error with variation in Measuring Frequency [A] . . . . . p. 3-1
3.1.2. Additional error [B] . . . . . p. 3-2

3.2. Measurements referred to a standard with the aid of a relay change-over switch . . . . . p. 3-4

4. APPLICATIONS AND CHARACTERISTICS . . . . . p. 4-1

4.1. Measurement principle . . . . . p. 4-1
4.2. Send Unit (Generator LDS-3) . . . . . p. 4-3
4.2.1. Carrier frequency generator ⑤ . . . . . p. 4-4
4.2.2. Modulation frequency generator ④ . . . . . p. 4-5
4.2.3. Modulator and output stage ③ . . . . . p. 4-5
4.2.4. Frequency counter ⑥ . . . . . p. 4-5

4.3. Receive Unit (Receiver LDE-3) . . . . . p. 4-6
4.3.1. Input amplifier ② . . . . . p. 4-6
4.3.2. Evaluation circuit ④ . . . . . p. 4-6
4.3.3. Display amplifier ③ . . . . . p. 4-7
4.3.3.1. Measuring group delay differences . . . . p. 4-7
4.3.3.2. Measuring of attenuation differences . . . p. 4-8
4.3.3.3. Measuring the receive level . . . . . p. 4-8

4.3.4. Frequency evaluation ⑤ . . . . . p. 4-9

5. MAINTENANCE AND ADDITIONAL INFORMATION . . p. 5-1

5.1. Checking the functions of the Measuring Set . . . . . p. 5-1
5.2. Removing the equipment panels . . . . . p. 5-1
5.3. Modifications, function checks and alignment of the ancillary devices . . . . . p. 5-2
5.3.1. Tone blocking filter, BN 615/11 . . . . . p. 5-2
5.3.2. Measuring Frequency remote control, BN 616/12 . . . p. 5-5
5.3.3. Buffer-store for level remote control, BN 615/11 . . . p. 5-7
5.3.4. Reference Frequency discriminator, BN 615/12 . . . . p. 5-8
5.3.5. Crystal controlled time base, BN 615/13 . . . . . p. 5-9
5.3.6. D.C. loop holding circuit, BN 615/14 . . . . . p. 5-12
5.3.7. Low-pass filter, BN 617/51 . . . . . p. 5-13

5.4. Changing fuses . . . . . p. 5-14
5.5. Shipping information . . . . . p. 5-14

BLOCK DIAGRAM LDS-3
BLOCK DIAGRAM LDE-3

INTRODUCTION

Up to the present time, for data transmission there has been available Telex networks. For higher speeds of transmission, the existing telephone channels must be used, but these were designed only for voice frequency transmission; that is the attenuation characteristics are pertinent to speech channels.

However, with faster transmission of data, definite requirements must be fulfilled with reference to variations with frequency not only for attenuation distortion but also for group delay distortion.

The variation of overall loss with frequency should be equalized at certain observable frequencies, and with private rented circuits, the limits for both overall loss and group delay are defined in Rec. M.102, CCITT.

With the use of the Measuring Set LD-3 which comprises the Generator LDS-3 and Receiver LDE-3, the group delay/frequency distortion as well as insertion loss (attenuation)/frequency characteristic can be precisely measured in the frequency range 200 Hz to 20 kHz.

This Measuring Set fulfills in all respects the new CCITT Rec. O.81, Geneva 1972, and furthermore offers additional essential advantages. Combined with the Attenuation and Delay Equalizer DLZ-1 from Wandel u. Goltermann, rapid and optimum equalization of a circuit can be accomplished. In addition to end-to-end measurements, the Measuring Set was designed for continous supervisory monitoring of data lines. Due to the well planned construction and dimensions of the Measuring Set LD-3, it is a real operational set, is easy to operate, is portable and is handy to use.

Of special advantage is the positive control of end-to-end measurements which are made with a Generator and a Receiver separated and in different locations. The only connection between Generator and Receiver is that through the circuit under test. The measurement accuracy achieved and the simple operating techniques used are essentially the same as those with loop-back measuring methods. The method of measuring is a further application of the well known Nyquist-principle in which two

carrier frequencies, a reference carrier and a measuring carrier, are alternately sampled for the purpose of referring the variation with frequency both of group delay and of attenuation (overall loss) to the fixed reference carrier frequency.

This method permits sweep measurements over a frequency range which is chosen in advance, and as well, point-to-point measuring. The measured result either can be read on a panel meter or graphically recorded on an X-Y plotter.

With end-to-end measurements, it often is of value that the measured result from the receive position is retransmitted to the first send position. This can be done by using two Measuring Sets LD-3. Herewith , the demodulated Measuring Frequency signal from the first Receiver LDE-3 is routed to a second Generator LDS-3, and in it a fixed Reference Frequency (carrier-frequency) is modulated with the signal coming from the first Receive Unit. With a fixed Reference Frequency (carrier-frequency), neither the insertion loss (attenuation)/frequency characteristic nor the group delay/frequency distortion of the return circuit are included in the retransmitted measured result routed to the second Receiver position. On the panel of the second Receiver which is with the first Generator (Send Unit), the measured result is indicated.

It also is possible to remotely control the Measuring Frequency, the Reference Frequency and the level transmitted by the Sender Unit. By this means, the relevant information from the Receiver LDE-3 is sent over a second channel to a remote location where a Generator LDS-3 is thus remotely controlled. The Generator LDS-3 can be operated in a way such that both the Modulation Frequency and the carrier change-over process can be switched off. As a result, the Measuring Set LD-3 can be used as a normal Level Measuring Set.

Generator LDS-3 and Receiver LDE-3 are fully compatible in the range to 20 kHz with the equipments of the Measuring Set for Group Delay and Attenuation LD-2 (frequency range 200 Hz to 600 kHz).

Facilities for loop holding are provided when optional inbuilt devices are fitted. These devices enable not only the Generator but also the Receiver to carry a d.c. holding current.

Generator and Receiver can be combined either separately or in common with an optionally chosen Speaker Facility LDZ-3. This provides the possibility of switching between measuring and speaking over the same line. Both types of circuits, either two-wire or four-wire, can be used. Through an internal loudspeaker, it is possible at any time to converse with operating personnel at the remote locations.

1. TECHNICAL SPECIFICATIONS

All values given are valid, unless otherwise noted, for the rated operating range of: the ambient temperature (+ 5 °C to + 50 °C), the mains voltage and frequency after an operating time of 10 minutes.

1.1. Complete Measuring Set

1.1.1. Frequency range . . . . . 200 Hz to 20 kHz

1.1.2. Group delay/frequency distortion $\Delta\tau g$

Measuring range for group delay/frequency distortion . . ± 0.05, ± 0.1, ± 0.2, ± 0.5, ..., ± 10 ms

Additional switchable group delay offset . . . . . + 5 ms ± 1 %

Accuracy of group delay measurements

in temperature range	Accuracy limits for measuring range in use	
+ 15 °C to + 35 °C	± 2 % of f.s.d.	} + A + B
+ 5 °C to + 50 °C	± 4 % of f.s.d.	

A : Additional error with variation in Measuring Frequency (Reference Frequency 1.8 kHz)

at:	
200 Hz	not greater than + 100 µs
400 Hz	not greater than + 30 µs
600 Hz	not greater than + 10 µs
from: 1 to 20 kHz	within ± 5 µs

B : Additional error in Receiver introduced by attenuation difference between Reference Carrier and Measuring Carrier in the level range - 40 dBm to + 10 dBm (Frequency range of Reference Carrier: . . . . . 400 Hz to 20 kHz)

at attenuation difference of:	
10 dB	not greater than ± 3 µs
20 dB	not greater than ± 5 µs
30 dB	not greater than ± 10 µs

Additional errors specified - at larger attenuation differences and in increased level range - in section 3 TECHNOLOGICAL INSTRUCTIONS and are explained therein.

1.1.3. Attenuation/frequency distortion Δa

Measuring range for attenuation/frequency distortion. . ±0.5, ±1, ±2, ±5, ..., ±50 dB

Accuracy of reading (Measuring Frequency = Reference Frequency) . . better than ± 3 % f.s.d. ± 0.05 dB

Additional error introduced by frequency response of the Receiver, referred to 1.8 kHz in range: 200 Hz to 20 kHz . . . . . less than ± 0.05 dB

1.2. Generator LDS-3

1.2.1. Frequency

1.2.1.1. Measuring Frequency (Readout on a 4 digit frequency counter) . . . . 200 Hz to 20 kHz

Error in the Measuring Frequency readout
in temperature range + 15 °C to + 35 °C . not greater than ± 0.5 %
in temperature range + 5 °C to + 50 °C . . not greater than ± 1 %
when equipped with crystal controlled
time base (BN 615/13) . . . . not greater than $\pm 1 \times 10^{-5}$
} ± 10 Hz

When using the decimal point shift, instead of ± 10 Hz resolution . . . ± 1 Hz

1.2.1.2. Reference Frequency, in 100 Hz steps and with vernier adjustment . . . . 400 Hz to 20 kHz

Error in the Reference Frequency
when using the counter readout . . . . . as with the Measuring Frequency

1.2.1.3. Modulation Frequency . . . . . 41.67 Hz

Accuracy of the Modulation Frequency:
in temperature range + 15 °C to + 35 °C . . . . . better than ± 0.5 %
in temperature range + 5 °C to + 50 °C . . . . . better than ± 1 %

Modulation depth . . . . . 0.4 ± 0.05
Modulation distortion factor. . . . . 1 %

$$\text{(Mod. dist. factor} = \frac{\text{RMS value of unwanted sidebands}}{\text{RMS value of wanted sidebands}} \times 100\ \%)$$

1.2.1.4. Identifying Frequency (= 4 x Modulation Frequency) . . . . . 166.67 Hz

Modulation depth . . . . . 0.2 ± 0.05

1.2.1.5. Change-over Frequency (= 1/10 x Modulation Frequency) . . . . 4.167 Hz

Carrier change-over time . . . . . less than 100 µs
Deviation between the carrier change-over
point and envelope minimum . . . . . not greater than ± 0.2 ms

1.2.1.6. Error introduced by Send Unit in the overall accuracy of the group delay measurement according to para. 1.1.2. (referred to Reference Frequency 1.8 kHz)

at: 200 Hz . . . . . not greater than + 10 µs
400 Hz . . . . . not greater than + 3 µs
from 600 Hz to 20 kHz . . . . . within ± 1 µs

1.2.2. Send level (unmodulated carrier oscillations)
coarse and fine settings . . . . . -50 to +11 dBm [1]

Send level setting "coarse" at 0 dB meter reading . . -40, -30, . . . , +10 dBm
Scale range of meter . . . . . -20 to + 1 dBm

1) The characteristic send level is larger by 0.33 dB as a result of the Measuring Carrier and the Reference Carrier being modulated with 41.67 Hz.

Error limits of the send level
in the level range - 44 to + 11 dBm and
in temperature range + 15°C to + 35°C . . . . not greater than ± 0.3 dB

for the level values, -40, -30, ..., +10 dBm
at the frequency 1.8 kHz and the meter
reading 0 dB . . . . . not greater than ± 0.3 dB

in level range -44 to +11 dBm . . . . . not greater than ± 0.5 dB

at rated operating conditions (meter reading
in scale range - 10 to + 1 dBm), ... not greater than ± 0.7 dB

1.2.3. Output . . . . . balanced, earth free

Output impedance . . . . . 600 Ω
(Output impedance: 150, 400, 800 or 900 Ω as requested)

Return loss . . . . . better than 40 dB ($r \leqq 0.01$)
Degree of balance (impedance balance ratio) . . . . . better than 46 dB

1.2.4. Spurious voltage

Harmonic distortion at 600 Ω load for
all settings of level and frequency . . . . . less than -46 dB

Spurious distortion . . . . . better than -60 dB

1.2.5. Sweep frequency device

Sweep limits, in 100 Hz steps including a vernier adjustment . . 200 Hz to 20 kHz

Sweep rate
Triangular wave shape sweep . . . . . 10, 20, 50, 100, 200 Hz/s
Single sweep "one shot" . . . . . 10, 20, 50, 100 Hz/s

The sweep can be optionally started or reversed

Output for voltage proportional to frequency . . . . 0 to + 5 V $\hat{=}$ 0 to 20 kHz
Output impedance . . . . . 5 kΩ

1.2.6. Retransmission of measured results

Possible by means of a second Measuring Set LD-3 without additional devices.

1.3. Receiver LDE-3

1.3.1. Input . . . . . balanced, earth free

Input impedance . . . . . 600 Ω
(Input impedance: 150, 400, 800 or 900 Ω as requested)

Permissible d.c. voltage a ‖ b measured to c . . . . . not greater than 100 V
Return loss . . . . . better than 40 dB ($r \leqq 0.01$)
Degree of balance (impedance balance ratio) . . . . . better than 46 dB

1.3.2. Level

Range of input level (absolute level) . . . . . -50 to + 10 dBm
Violations of range limits signalled with lamps

Ranges of absolute level measuring for 0 dBm meter reading. . . -40, -30,... , 0 dBm

Meter scale range. . . . . - 10 to + 10 dBm
The reading is switchable from Measuring Signal to Reference Signal

Accuracy for a meter reading of the reference carrier oscillation at 1.8 kHz, after 1 hour operating time, meter reading 0 dBm or + 10 dBm
for levels from - 20 to + 10 dBm
in temperature range + 15 °C to + 35 °C . . . . . better than ± 0.25 dB
in temperature range + 5 °C to + 50 °C . . . . . better than ± 0.7 dB

Accuracy for a meter reading of measuring or reference carrier oscillation, after 1 hour operating time
for levels from - 20 to + 10 dBm
in the temperature range + 15 °C to + 35 °C . . . . better than ± 0.4 dB
in the temperature range + 5 °C to + 50 °C . . . . better than ± 0.75 dB

for levels from - 40 to + 10 dBm
in the temperature range + 15 °C to + 35 °C . . . . better than ± 0.65 dB
in the temperature range + 5 °C to + 50 °C . . . . better than ± 1,1 dB

1.3.3. Group delay/frequency distortion $\Delta\tau g$

Information as to measuring ranges and accuracy of group delay measurements . . . . . see para. 1.1.2.

Additional error, introduced by the Receiver (Reference Frequency 1.8 kHz), with variation in Measuring Frequency and included in the total error of the group delay/frequency distortion measurement according to para. 1.1.2.
at 200 Hz . . . . . not greater than + 90 µs
at 400 Hz . . . . . not greater than + 27 µs
at 600 Hz . . . . . not greater than + 9 µs
from 1 to 20 kHz . . . . . within ± 4 µs

For the additional error due to attenuation differences between Reference Signal and Measuring Signal . . . . see para. 1.1.2.

1.3.4. Attenuation/frequency distortion Δa

Information as to measuring ranges and accuracy of the attenuation measurements . . . . . see para. 1.1.3.

1.3.5. Frequency indication (with a 4 digit frequency counter) . . . . . 200 Hz to 20 kHz

Error of indication
in temperature range + 15 °C to +35 °C . . not greater than ±0.2 %
in temperature range +5 °C to +50 °C . . not greater than ±0.4 %
with crystal controlled time
base (BN 615/13). . . . . not greater than $\pm 1 \times 10^{-5}$
} ± 11 Hz

With operation of the decimal point shift, instead of ± 11 Hz resolution . . ± 2 Hz

1.3.6. D.C. voltage outputs

Y output
for voltage proportional to one of the measured values (absolute level, group delay/frequency distortion or attenuation/frequency distortion

Voltage range. . . . . ±2.5 V for full scale deflection in plus or minus direction

Output impedance . . . . . 5 kΩ

X output
for voltage proportional to frequency (verified via internal frequency counter)

Voltage range for the frequency range 200 Hz to 20 kHz . . approx. 0 to + 5 V

Output impedance . . . . . 5 kΩ

Frequency markers . . . . . adjustable through frequency indication

1.3.7. Effects of noise interference signals

RMS value of the error in indication due to a white noise level of 26 dB per 4 kHz bandwidth below the mean carrier level of the received test signal

in setting "slow" . . . . . not greater than 20 µs
in setting "fast" . . . . . not greater than 60 µs

In setting "slow", a sweep rate of 20 Hz is possible provided that the group delay/frequency distortion $\Delta\tau g$ of the circuit under test does not vary at a rate exceeding 1.5 ms/100 Hz.

Peak value of the error in indication
with interference due to a discrete frequency 26 dB below the mean carrier level and separated by ± 150 Hz from Measuring
Frequency or Reference Frequency . . . . . not greater than 20 µs
separated by ± 200 Hz from Measuring
Frequency or Reference Frequency . . . . . not greater than 2 µs

1.3.8. Retransmission of measured results
without additional equipment except for a second Measuring Set LD - 3

1.4. General specifications of the Measuring Set LD-3

1.4.1. Ambient temperature

Storage and transport	- 40 °C to + 70 °C
Rated operating range (≙ limits of operating range)	+ 5 °C to + 50 °C

1.4.2. Power supply

Rated operating range of mains voltage	110/117/127/220/227/235 V within - 15 % to +10 %
Rated operating range of mains frequency	45 to 66 Hz
Power consumption: Send Unit LDS-3	approx. 40 VA
Receive Unit LDE-3	approx. 40 VA

1.4.3. Dimensions

Send Unit LDS-3 or Receive Unit LDE-3 (individual units with folding handles)

Width with handle	233 mm
Height overall	155 mm
Depth overall	390 mm

1.4.4. Weight

Send Unit LDS-3	7.2 kg
Receive Unit LDE-3	7.2 kg

1.5. Ancillary devices (if requested, available for purchase)

1.5.1. Speaker Facility LDZ-3

Change-over possibilities between measuring operation and speech operation. For speech operation, a telephone set, a field telephone or a microphone can be connected by means of a pair of terminals. When changing-over between measuring and speaking, the loop is held.

Loudspeaker

No affect on performance of Send Unit or Receive Unit while loudspeaker is used during measuring

Hybrid connection

Internal hybrid connection for conversations on four wire circuits

Dimensions and weight

The Speaker Facility LDZ-3 must be combined with Generator LDS-3 and Receiver LDE-3, and the resulting unit has carrying handles side-mounted.

Width with handles	478 mm
Height overall	199 mm
Depth with handles	407 mm

Weight of measuring Set LD-3 including Speaker Facility . . . . . 18 kg

1.5.2. Low-pass filter

The low-pass filter is used for reducing interference and for suppression of 16 kHz unit cost counter pulses

Additional group delay error to 4 kHz	<10 µs
Additional attenuation/frequency distortion error to 4 kHz	<0.1 dB

The low-pass filter is offered as an additional circuit board for the Speaker Facility LDZ-3.

1.5.3. Tone blocking filter

Number of blocked frequencies	max. 2
Blocked frequencies, optionally fitted in the range	1.6 to 20 kHz
Blocked range, referred to the pertinent blocked frequency	± 150 Hz

The tone blocking is done with an extra card in Send Unit LDS-3

1.5.4. D.C. loop holding circuit

Maximum permissible holding current	100 mA
Voltage drop across the holding circuit with maximum current	not greater than 13 V

Dynamic output impedance in the range
200 Hz to 5 kHz . . . . . not less than 20 kΩ
> 5 to 20 kHz . . . . . not less than 15 kΩ
Degree of balance (impedance balance ratio) . . . . . approx. 50 dB

The d.c. loop holding circuit is arranged on an extra card for the Send Unit LDS-3 and the Receive Unit LDE-3.

1.5.5. Crystal controlled time base for frequency counter

Error of the crystal controlled time base
(see also paras. 1.2.1.1. and 1.3.5.) . . . . . not greater than $\pm 1 \times 10^{-5}$

The crystal controlled time base comprises the extra cards, "1 MHz Oscillator" and "Frequency divider" which can be retrofitted to the Send Unit LDS-3 and the Receive Unit LDE-3.

1.5.6. Remote control of the Send Unit LDS-3

Remote controllable are: . . Level, Measuring Frequency and Reference Frequency

Extra cards necessary for remote control capability
Buffer-store for level remote control (for fitting into Receive Unit LDE-3)
Reference Frequency discriminator (for fitting into Receive Unit LDE-3)
Measuring Frequency remote control (for fitting into Send Unit LDS-3)

1.6. Order numbers

Receive Unit LDE-3 . . . . . BN 615
Send Unit LDS-3 . . . . . BN 616

Measuring Set LD-3 with Speaker Facility LDZ-3
(19" case with carrying handles on sides) . . . . . BN 617/20

Extra circuit boards for Receive Unit LDE-3:

Buffer-store for level remote control . . . . . BN 615/11
Reference Frequency discriminator . . . . . BN 615/12
Crystal controlled time base (1 MHz oscillator
and frequency divider) . . . . . BN 615/13
D.C. loop holding circuit . . . . . BN 615/14

Extra circuit boards for Send Unit LDS-3:

Tone blocking filter . . . . . BN 616/11
Measuring Frequency remote control . . . . . BN 616/12
Crystal controlled time base (1 MHz oscillator
and frequency divider) . . . . . BN 615/13
D.C. loop holding circuit . . . . . BN 615/14

Extra circuit board for Speaker Facility LDZ-3:

Low-pass filter. . . . . BN 617/51

When ordering, in addition to the order number, it is necessary to provide additional information:

- whether Send Unit LDS-3 and Receive Unit LDE-3 are wanted as single units (1/2 of 19" case) with folding handles or combined as a 19" equipment with side mounted carrying handles.
- chosen output and input impedances of Send Unit and Receive Unit
- chosen blocked tone frequencies (max. 2) for extra board "Tone blocking filter"

Subject to change without notice

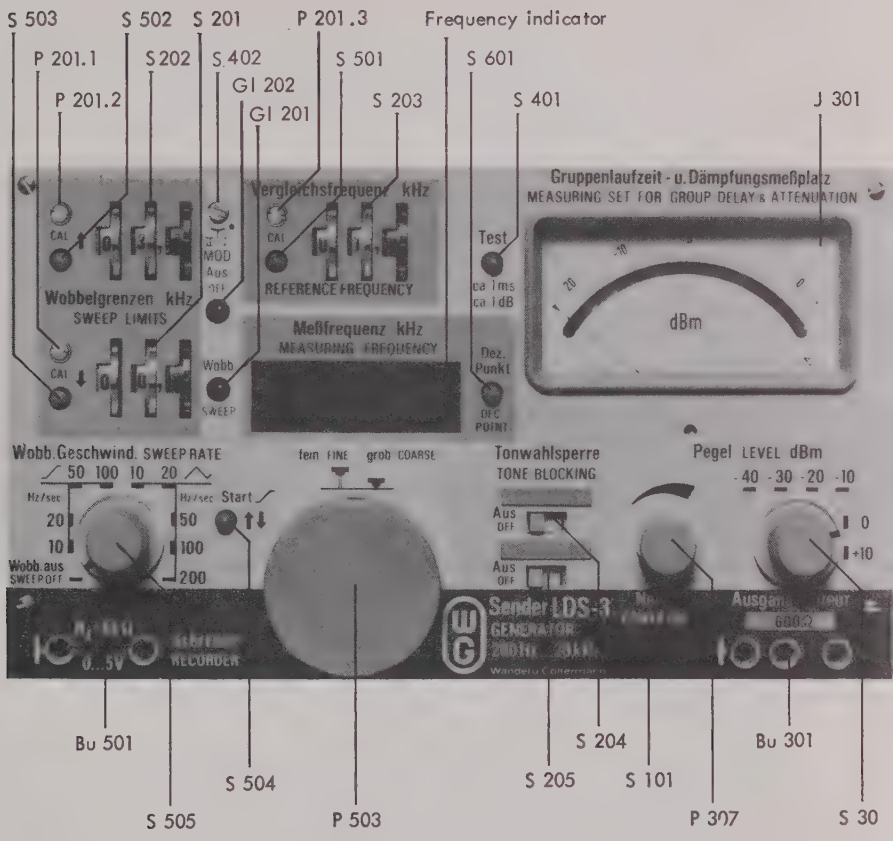


Fig. 2-1 Front view of Generator LDS-3

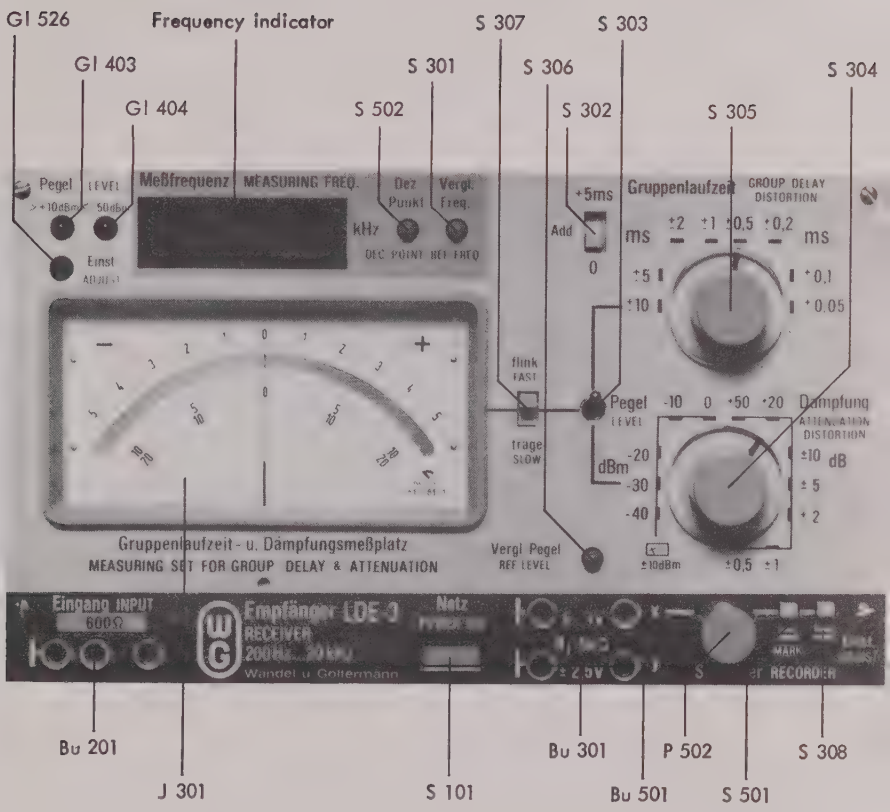


Fig. 2-2 Front view of Receiver LDE-3

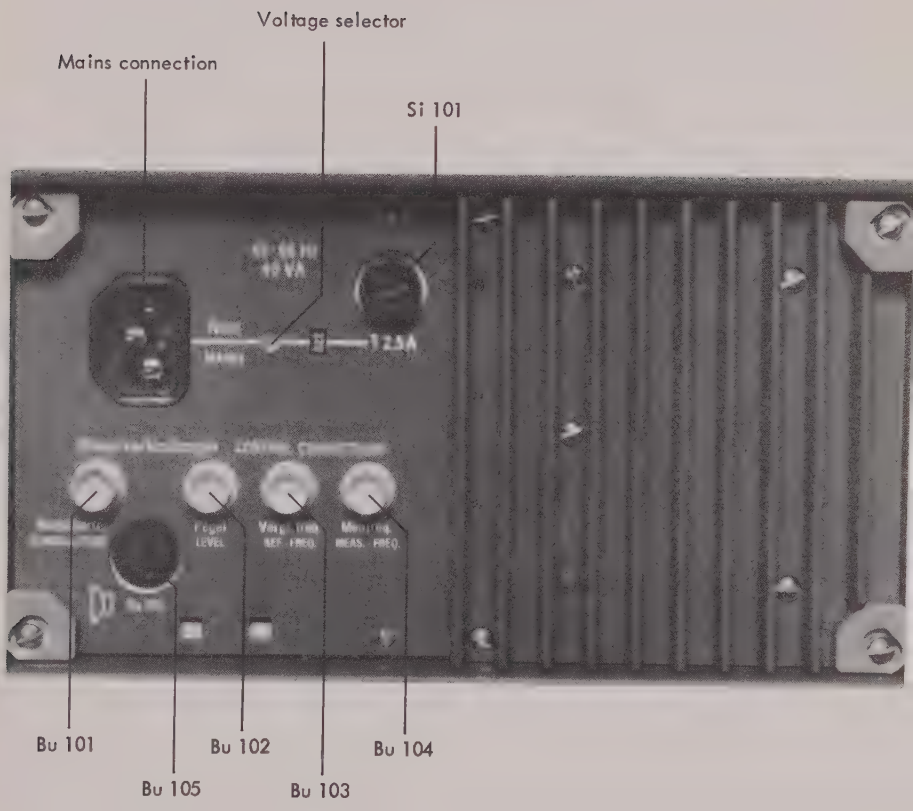


Fig. 2-3 Rear view of Generator LDS-3 and Receiver LDE-3

2. OPERATION

2.1. Operating controls

The operating controls, indicating devices, output terminals and input terminals are functionally arranged on the front panel. The mains plug, mains voltage selector switch and equipment fuse are located on the back-panel of the equipment. An exact labeling arrangement, plus the use of graphic symbols provide the functional relationships of correlated operating controls and therewith ensure the correct operation of the Measuring Set.

The functions of the operating controls are explained in the following with reference to the abbreviations as shown on the illustrations of the front views and the rear view of the equipments (Fig. 2-1 to Fig. 2-3).

2.1.1. Generator LDS-3 (Send Unit), see Fig. 2-1

Abbreviation	Front panel marking	Function
Bu 301	OUTPUT	Connector terminal for the circuit under test
S 301	LEVEL	Coarse settings in 10 dB steps
P 307		Vernier adjustment of send level
J 301		Range of meter scale from - 20 to + 1 dBm mechanical zero point at " ▼ "
P 503		Measuring frequency setting (Switch S 505 in setting "Sweep OFF") Position : coarse setting Position : fine setting
	MEASURING FREQUENCY (Frequency counter with digital readout)	Indication of Measuring Frequency through 4 seven segment figures and with 10 Hz resolution.
S 601	DEC POINT	While depressed: the counter readout is changed-over from a resolution of 10 Hz to that of 1 Hz; the 10 kHz position is eliminated.
S 203	REFERENCE FREQUENCY	Digital settings of Reference Frequency in 100 Hz steps from 0.4 to 19.9 kHz.

S 501			While depressed: the Reference Frequency is sent during the measuring cycle and the reference cycle, and the frequency is indicated.
P 201.3	CAL		Vernier adjustments of the Reference Frequency within the 100 Hz steps of S 203 while push button S 501 is depressed.
S 202	⬆		Digital setting in 100 Hz steps of the upper sweep limit in the frequency range 0.2 to 19.9 kHz.
S 502			While depressed: the Measuring Frequency takes the value of the upper sweep limit with a simultaneous counter readout; determination of the upper sweep limit as the commencement value with swept operation.
P 201.2	CAL		Vernier adjustment of upper sweep limit within the 100 Hz steps of S 202 while push button S 502 is depressed.
S 201	⬇		Digital setting in 100 Hz steps of the lower sweep limit in the frequency range 0.2 to 19.9 kHz.
S 503			While depressed: the Measuring Frequency takes the value of the lower sweep limit with a simultaneous counter readout; determination of the lower sweep limit as the commencement value with swept operation.
P 201.1	CAL		Vernier adjustment of lower sweep limit within the 100 Hz steps of S 201 while push button S 503 is depressed.
S 505	SWEEP RATE		In setting "Sweep OFF", manual setting of the Measuring Frequency can be made with P 503; with single trigger sweep ⌐, 4 sweep rates; with triangular wave shaped sweeps, 5 sweep rates can be set.
S 504	START ⌐ ⬆⬇		With single trigger sweep, start button; during a sweep, if this push button is depressed, then the sweep direction is reversed.
GI 201	SWEEP		Blinker indicator with swept operation
S 402	MOD	•	Carrier frequency change-over switched ON (Normal operation).
		I	Carrier frequency change-over switched OFF.
		II	Carrier frequency change-over and 41.67 Hz Modulation Frequency switched OFF.

Gl 202	MOD OFF	Blinker indicator for S 402 at positions I or II
S 401	TEST	While the push button is depressed, the indication at the Receiver is changed by approx. + 1 ms or by approx. + 1 dB.
Bu 501	RECORDER	Output for d.c. voltage proportional to frequency (0 to 5 V ≙ 0 to 20 kHz)
S 204, S 205	TONE BLOCKING	With in-built tone blocking filters, these are switchable for ON and OFF
S 101	POWER ON	Mains switch (switch cap illuminates in red colour when unit is "ON")

2.1.2. Receiver LDE-3 (Receive Unit), see Fig. 2-2

Abbreviation	Front panel marking	Function
Bu 201	INPUT	Connector terminal for the circuit under test
Gl 403 Gl 404	LEVEL > + 10 dBm < - 50 dBm	Input level monitoring; indication occurs when limits are violated
	MEASURING FREQUENCY (Frequency counter with digital readout)	Indication of received Measuring Frequency through 4 seven segment figures and with 10 Hz resolution
S 502	DEC POINT	While depressed: the counter readout is changed-over from a resolution of 10 Hz to that of 1 Hz; the 10 kHz position is eliminated.
S 301	REF FREQ	Indication of the received Reference Frequency instead of the Measuring Frequency while the push button is depressed.
S 305	GROUP DELAY DISTORTION	Measuring range switch having 8 ranges between ± 0.05 and ± 10 ms for the group delay/frequency distortion.
S 302	ADD 0 + 5 ms	Normal setting Group delay offset by + 5 ms; combined with S 305, a maximum positive group delay offset of + 15 ms is measurable.
S 304	ATTENUATION DISTORTION/ LEVEL	Measuring range switch with 7 ranges between ± 0.5 and ± 50 dB for attenuation/ frequency distortion characteristic and 5 ranges for the absolute input levels (the Measuring Signals); with absolute level measuring, the values are read in the ± 10 dBm scale range

S 306	REF LEVEL	While depressed: the level of the Reference Signal (instead of the input level of the Measuring Signal) is indicated on the meter.
S 303	(ms-dB/dBm)	Change-over of both the meter reading and the Y output from group delay/frequency distortion to attenuation/frequency distortion or absolute level.
S 307	FAST/SLOW	Change-over between faster or slower meter indications for suppressing disturbances due to the circuit under test, the change-over occurs also at the X-Y plotter outputs and the frequency readout.
J 301		According to the switch setting of S 303, the meter reading is for either group delay/frequency distortion or attenuation/frequency distortion characteristic or absolute level; the meter has 3 scale ranges; with absolute level readings, the scale range of ± 10 dBm is valid.
Bu 501	X	Output for a d.c. voltage proportional to frequency for the connection of an X-Y plotter; 0 to + 5 V ≙ 0 to 20 kHz
Bu 301	Y	Output for a d.c. voltage proportional to the measured value ($\Delta\tau g$, Δa, a) for the Y deflection of a plotter; ± 2,5 V for plus or minus full scale deflection of the meter.
S 308	ADJUST	In position " ADJUST" the X-Y plotter can be calibrated.
Gl 526	ADJUST	While S 308 is in the position " ADJUST" this indicator blinks.
P 502		For setting an optional "Measuring Frequency" between 200 Hz and 20 kHz: 1. to calibrate the X axis of a plotter 2. to generate a frequency marker. The "set-up" frequency appears at the frequency readout.
S 501	MARK	In the setting "MARK", the frequency "set-up" with P 502 causes a frequency marker to occur with X-Y plotter operation.
S 101	POWER ON	Mains switch (switch cap is red colour when unit is "ON").

2.1.3. **Back panel of Generator LDS-3 (Send Unit) and Receiver LDE-3 (Receive Unit), see Fig. 2-3**

The back panels are identical on both Generator and Receiver, and it is sufficient to illustrate with one rear view. The abbreviations used for AF and coaxial connectors also are the same for Generator and Receiver.

Abbreviation	Marking on the back panel of the equipment	Function
Bu 101	REMODULATION	Remodulation (retransmission) of the measured result from receive position to send position (measurement mode described in para. 2.6.)
Bu 102	LEVEL	Remote control of a second Generator as pertaining to level, Measuring Frequency and Reference Frequency (Measurement mode described in para. 2.8.6.)
Bu 103	REF-FREQ	
Bu 104	MEAS-FREQ	
Bu 105		Connector jack for loudspeaker
Si 101	T 2.5 A	Equipment protective fuse (Rated current 2.5 A, slow-blow)
	MAINS	Mains connection

2.2. Connections and setting-up instructions

The units of the Measuring Set LD-3 can be used on a.c. mains having frequencies between 45 and 66 Hz. When shipped from the factory, the mains voltage selector switches located on the Generator LDS-3 (Send Unit) and the Receiver LDE-3 (Receive Unit) are set to 220 V. However, according to the available mains voltage, the selector switch can be changed with a screw driver, and there is a choice of 110, 117, 127, 227 or 235 V. The selected voltage is visible through a cut-out on the back panel.

Mains voltage variations from + 10 % to - 15 % of the pertinent selected mains voltage are permissible. Moreover, the performance characteristics, as given in section 1 TECHNICAL SPECIFICATIONS, of the Measuring Set are not affected when the units are operated within the limits of mains voltage variations.

Changing the fuse for different mains voltage is not necessary. Furthermore, both units have mains power cords with protective conductors connected to the chassis-

grounds. Therewith, the units conform with recommendations of the safety code in Germany, VDE 0411.

The units are operational immediately after being switched ON with power switch S 101.

If Generator LDS-3, Receiver LDE-3 and Speaker Facility LDZ-3 (available on order) are combined to form a unified Measuring Set, then the mains power cord is stored in a compartment on the bottom of the Speaker Facility, and after opening the compartment with the two wing nuts, the plug of the mains cord is accessible for connection to the mains voltage.

2.3. Operation of the Send Unit

2.3.1. Level setting

Coarse setting of send level in 10 dB steps is done with switch S 301. The setting values of - 40, - 30, ..., + 10 dBm are valid with the meter reading at 0 dBm. (Blocking the + 10 dBm position is possible, if requested)

Fine setting of the send level is done both with potentiometer P 307 and with meter J 301. The scale range of the meter is approx. 20 dB. Send level value is given by the algebraic addition of the coarse setting value and the meter reading.

The Send Unit has a balanced, earth free output (Bu 301) having an output impedance of 600 Ω (also at special request for 150, 400, 800 or 900 Ω).

2.3.2. Frequency setting and readout

The Measuring Frequency is set by means of the large rotary knob P 503 which has a coarse and fine drive mechanism. By easily pulling out the knob, the position "fine" (vernier adjustment) can be used. The range of frequency settings lies between 200 Hz and 20 kHz. The Measuring Frequency is indicated with a 4 digit readout on the panel mounted frequency counter. Push button switch S 601 changes-over the counter readout from a resolution of 10 Hz to that of 1 Hz; whereby, the 10 kHz position of the readout is eliminated.

The Reference Frequency can be set in steps of 100 Hz with switch S 203 in the range 400 Hz to 20 kHz. Within each 100 Hz step, the Reference Frequency can be vernier adjusted with a screw driver at slotted shaft-head potentiometer P 201.3 .

While push button switch S 501 is depressed, the Reference Frequency instead of the Measuring Frequency can be measured and displayed with the inbuilt frequency counter; thereby, the Measuring Frequency jumps to the Reference Frequency.

Setting and readout of the upper and lower sweep limits results from a similar procedure as with the Reference Frequency.

2.4. Operation of the Receive Unit

2.4.1. Input level range and monitoring input level

The signal coming from the circuit under test is applied to the Receive Unit input, Bu 201. The input is balanced and earth free and has an input impedance of 600 Ω. (also at special request for 150,400,800, or 900 Ω).
The permissible range of the input level encompasses from - 50 to + 10 dBm. The Receive Unit does not require matching the sensitivity of it to the input level.
Violation of the lower or upper limits of the permissible input level range is indicated with the lamps Gl 403 (> + 10 dBm) and Gl 404 (< - 50 dBm).

The input level of Measuring Signal or Reference Signal can be measured in absolute values and can be read on meter J 301 (see para. 2.4.3.3.).

2.4.2. Frequency readout

The received Measuring Frequency (200 Hz to 20 kHz) is measured with the inbuilt frequency counter and is digitally illuminated with a resolution of 10 Hz. For a reading of the frequency measuring result with a resolution of 1 Hz, push button S 502 is depressed; thereby, the 10 kHz position is eliminated.

The Reference Frequency (400 Hz to 20 kHz) instead of the Measuring Frequency can be read on the frequency readout while push button S 301 is depressed.

2.4.3. Measured result indication

The meter J 301 has three scale ranges and indicates,according to the selected toggle switch (S 303) position, the group-delay/frequency distortion or attenuation/ frequency distortion characteristic or the absolute input level.

With slide switch S 307, the suppression of interference through the circuit under test can be changed-over from " fast" to " slow" indications of measurement results.

2.4.3.1. Group delay/frequency distortion $\Delta\tau g$

When caused by the circuit under test, the difference in group delay between Measuring Signal and Reference Signal can be measured with the toggle switch S 303 in the upper position, and the difference can be read on meter J 301.

Selecting the measuring range is done with switch S 305. It permits a selection of 8 measuring ranges between ± 0.05 and ± 10 ms. The pertinent range which is selected is referred to plus or minus full scale deflection of the meter and includes the correlated scale multiplier.

According to the selected measuring range, one of the three meter scales is read for the measured result.

The slide switch S 302 enables a constant 5 ms offset in the indicated value of group delay/frequency distortion. Therewith, the receiver can be used to measure up to + 15 ms difference in group delays.

2.4.3.2. Attenuation/frequency distortion characteristic Δa

The attenuation difference between Measuring Signal and Reference Signal is measured and indicated when toggle switch S 303 is switched to the lower position.

Switch S 304 enables selection of 7 measuring ranges for reading attenuation distortio between ± 0.5 and ± 50 dB.

2.4.3.3. Receive level

In 5 additional settings of switch S 304, absolute measurement of the input level is possible. The selectable values of - 40, - 30, ..., 0 dBm are valid with the meter pointer reading at 0 . With absolute level measuring, the meter has a scale range of ± 10 dBm. The meter indicates the carrier level of the Measuring Signal. While push button S 306 is depressed, the Reference Carrier can be read on the meter.

2.5. Measuring

For examination of the frequency characteristics of the group delay distortion and attenuation distortion due to a circuit under test, the application of the carrier change-over method is selected. With this method, the measured result is referred to the Reference Frequency. Therefore, the absolute values of group delay/frequency distortion and attenuation/frequency distortion are not obtained, but instead, their differences are obtained with reference to their values at the Reference Frequency.

With respect to the operation of the Measuring Set, there is no difference between end-to-end measurements and loop-back measurements. For end-to-end measurements, it is possible to use the Speaker Facility LDZ-3 on the line being measured because speech communication with the remote location where the end measurements are being made facilitates the measurement procedure (see para. 2.8.1.).

2.5.1. Point-by-point measurements

Before commencement of measurements, it is necessary to observe that the switch S 505 (on the Send Unit) is set at "SWEEP OFF" and switch S 402 is in setting "•". At the Receive Unit, the switch S 308 must not be in setting "ADJUST".

The circuit under test is connected between Generator output Bu 301 and Receiver input Bu 201.
The chosen send level is set with switch S 301 and potentiometer P 307. For purposes of having a large signal-to-noise ratio, the highest possible send level should be selected. However, the load capacity should not be exceeded for the system which is being measured. Send levels larger than 0 dBm are not usually used these days.

Thereupon, the Reference Frequency can be set with the thumb-wheel decade switches S 203. The Reference Frequency can be freely selected within the transmission range of the circuit under test. CCITT Recommendations suggest the Reference Frequencies which are preferred for use. Moreover, a Reference Frequency of 1.8 kHz is suggested in the new CCITT Equipment Specification for a Group Delay/Frequency Distortion and Attenuation/Frequency Distortion Measuring Set. For measuring attenuation distortion (overall loss) on rented lines, a Reference Frequency of 800 Hz is

to be used according to CCITT Recommendation M. 102. The Reference Frequency for group delay distortion according to M. 102 is that frequency at which the minimum point occurs for a curve of group delay distortion.

After setting the level and setting the Reference Frequency, it is thereupon necessary to observe that the input level range of the Receiver is neither over exceeded nor unde achieved. (Monitoring indicators GI 403 and GI 404).

If the above cited preparatory settings have been made, then the Measuring Set LD - 3 is operationally ready for point-by-point measurements:

Generally, the first measurement is that for receive level. Thereto, toggle switch S 303 on the Receive Unit is switched "down".

Additionally the attenuation/frequency distortion characteristics should be measured as referred to the Reference Frequency. The measuring range switch S 304 is switched-over from level ranges to attenuation distortion ranges.

For group delay/frequency distortion measurements, toggle switch S 303 is switched "up". If the CCITT Recommendation M. 102 is used for guidance, then the Reference Frequency setting, as described previously, is to be newly used.

The measuring range switch S 305 is set for purposes of the highest measuring accuracy so the largest possible deflection of the pointer is obtained.

With group delay measurements, there is permitted a max. of 50 dB attenuation difference between Measuring Signal and Reference Signal. In the Receive Unit, as a consequence, there is a group delay frequency/distortion error caused by the attenuation difference between the Measuring Signal and the Reference Signal. This error is given in para. 1.1.2.

Information: With the switching-over of the frequency readout from Measuring Frequency to Reference Frequency at the Send Unit during point or sweep measurements, the measuring level indication also changes at the Receive Unit because in the measuring cycle, the Reference Frequency is sent instead of the Measuring Frequency. In a corresponding way, the frequency readout changes due to the frequency jump between upper and lower sweep limits. During the use of an X - Y plotter there could be an unintentional change-over in frequency indication, at the Send and

Receive Units, and the recorder pen should be prevented from recording the jump from high to low frequency. If the pen were to reverse direction, it could damage the plotted recording.

2.5.1.1. Test circuit

For rapid verification of the functions of the Measuring Set LD-3, it is fitted with a test circuit which is effective not only with a direct connection between Send Unit and Receive Unit but also with a connection through the circuit under test.

While push button switch S 401 is depressed at the Send Unit, the meter on the Receive Unit indicates a measured result of either approx. + 1 ms or approx. + 1 dB according to the setting of toggle switch S 303. If the circuit under test is between the Send Unit output and the input to the Receive Unit, then the above mentioned values are added to the true measured values.

2.5.2. Sweep measurements

The information given in para. 2.5.1. is required also in the use of sweep measurements.
The "setting-up" of send level and Reference Frequency is done as with that for point-by-point measurements.

At the Send Unit, the lower and upper sweep limits are set with thumb-wheel switches S 201 and S 202 resp. Push button switches S 503 and S 502 and potentiometers P 201.1 and P 201.2 are used for vernier adjustment of the sweep limits. The adjustments for Reference Frequency as described in para. 2.3.2. are simular to those adjustments for upper and lower sweep limits.
Since during sweep operation, there should be no possibility arising for the need to change measuring range indication of group delay/frequency distortion or of attenuation/frequency distortion, the measuring range switches S 304 and S 305 are to be set to that meter range which does not permit exceeding full scale deflection. For this operating method, the Measuring Frequency is manually tuned over the frequency range of interest, whereby beforehand, the Reference Frequency is set according to the meas-

urement mode. With the choice of range, the decision is made after the appearance of the highest measured values.

Generally, however, the measured values are the largest magnitudes at the band limits, so it is sufficient that the upper and lower sweep limits be first set and then measured after depressing push button switches S 502 and S 503 in that same sequence. Now the choice of sweep rate can be made with switch S 505. The sweep rate to be selected depends upon the smooth response with frequency change. If the circuit under test has a flat frequency response, then the sweep rate can be increased. However, to enable identification of very narrowband variations, a low sweep rate should be selected.

With switch S 505, both the selection of sweep rate and the determination of the swee mode can be made:
single sweep (⟋⎺) of the selected frequency range or recurrent (continuous) sweep (⋀⋁).

After a sweep has commenced, push button S 504 can be depressed to reverse the sweep direction. Furthermore, depressing push button S 504 triggers a single sweep ("one shot").

Whether the sweep is started from the upper or the lower sweep limit is determined with push buttons switches S 502 and S 503. When in swept mode, the indicator lamp Gl 201 blinks.

2.5.2.1. X-Y plotter operation

For recording the measured results derived from sweep measurements, an X-Y plotter can be connected to the Receive Unit. For this purpose, at connector Bu 501, there is the X d.c. deflection voltage proportional to the Measuring Frequency, and at connector Bu 301, there is the Y d.c. deflection voltage proportional to the measured values.

The zero point calibration of the plotter is done with the Receive Unit disconnected, and the plotter input should be short circuited.

For calibrating the full distance of pen travel, the plotter should be connected to the

Receive Unit. Furthermore, slide switch S 308 should be set to "ADJUST "(indicator lamp Gl 526 blinks!).

At the frequency readout, a frequency value is displayed which can be varied with potentiometer P 502 between 200 Hz and 20 kHz.

The d.c. voltage at the X output is proportional to the "set-up" frequency. It is useful to select the value of the upper sweep limit as the frequency. If slide switch S 501 is placed in position "MARK", then with potentiometer P 202,a frequency can be set which appears as a frequency mark on the plotted curve.

During the calibrating process, there is at the Y output,Bu 301,a d.c. voltage corresponding to full scale deflection of the meter.

The most efficient use of the graphic recorder paper is achieved by means of changing measuring ranges at the X-Y plotter. After calibration, switch S 308 is returned to the upper position.
Special graph paper with a printed tolerance template for use with X-Y recorders having DIN A 4 recording area (210 mm x 297 mm) can be delivered if ordered. The order numbers for the pads of graph paper are: BN 5/267 a (attenuation frequency distortion) and BN 5/267 b (group delay/frequency distortion).

The graphic recording paper also is used with the line conditioning equipment, Attenuation and Delay Equalizer DLZ-1 from Wandel u. Goltermann.

2.6. Retransmission of the measured results

With end-to-end measuring, it is possible to retransmit measurements from remote location B back to the sender location A. Thus, group delay/frequency distortion and attenuation/frequency distortion can be measured between A and B, and by using a second Measuring Set LD-3 plus a second transmission channel, the measured results can be transmitted back to A. There are no special requirements levied on the line used for the retransmission. The following circuit can be arranged for the retransmission of measured results:

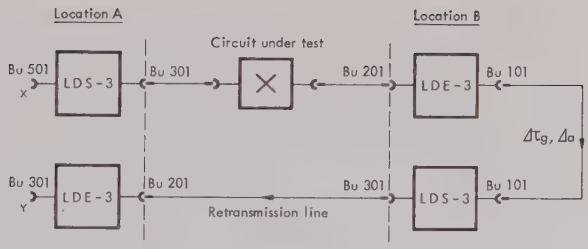


Fig. 2-4 Retransmission of measured results from location B to location A

In location B, for this operating mode, the retransmission connector Bu 101 of the Receive Unit is connected by means of a BNC cable to the Bu 101 connector of the Send Unit. These connectors are on the back panels of both Units.

At location B, the Receiver produces the envelope signal, containing the phase surge and the amplitude surge, and the signal is routed through the cable connection to the Send Unit. Here, for the case of the retransmission mode, the Reference Frequency is continuously sent, and the envelope signal modulates it. The chosen Reference Frequency is set with the switch S 203; herewith, for frequency readout, the push button S 501 should not be depressed. Preferably the Reference Frequency of 1.8 kHz should be chosen for measurements on telephone circuits. Due to the Send Unit, at location B, operating as an amplifier when in retransmission mode, the matching of levels to the retransmission path is done with the coarse level switch S 301 settings in 10 dB steps, thus, the level fine setting is out of operation. If the switch S 301, for instance, is placed in position "0 dBm" then the gain of the Sender is 0 dB. That means the signal fed to the line carrying the retransmission has the same level as the input signal at connector Bu 201 of the receiver at location B . The meter on the Send Unit does not indicate the level of the retransmitted signal, therefore the receive level at location B is measured in order to decide which setting of the coarse level switch S 301 is required.

At the Receiver in location A, there is the usual accuracy of measurement for group delay/frequency distortion and attenuation/frequency distortion.

For recording the measured results, in location A an X-Y plotter can be connected. The d.c. voltage proportional to the Measuring Frequency is taken from the Send

Unit, connector Bu 501, for the X deflection because the Measuring Frequency cannot be recovered from the retransmitted signal. For the Y deflection, there is, at connector Bu 301 of the Receive Unit, a d.c. voltage proportional to the measured result.

2.7. Additional possibilities for application

2.7.1. Operated as Level Measuring Set and as Swept Frequency Measuring Set

By means of switching off the modulation and carrier change-over process, the Generator LDS-3 can be used as a normal Level Generator and Swept Frequency Generator. Switch S 402 is only set to position "II" with a screw driver. The sinusoidal signal at the output of the Generator can be varied in the frequency range, 200 Hz to 20 kHz. Level, frequency and sweep limits are adjusted as previously explained.

When the switch S 402 is changed-over from carrier change-over operation to either position "I" or "II", the indicator lamp, Gl 202, blinks (for explanation of switch position "I" of S 402, see para. 3.2.).

The Generator LDS-3 together with the Receiver LDE-3 can be extended into becoming a Level Measuring Set or a Swept Frequency Measuring Set because the Receiver can be used as a Wide Band Level Meter for measuring unmodulated signal levels. For precise frequency response measurements of the attenuation distortion, however, it is best to return to the method of carrier change-over, and thus make use of the high resolution of measuring "Δa".

Generator LDS-3 and Receiver LDE-3 can be used with corresponding equipment manufactured by other firms whereby Level Measuring Sets or Swept Frequency Measuring Sets can be made-up.

2.7.2. Receiver LDE-3 as a Frequency Counter

The Receiver LDE-3 also can be used as a Frequency Counter. For the measured frequency, a resolution of 1 Hz is possible with the use of decimal point shift. At an ambient temperature between + 15 °C and + 35 °C the readout error is smaller than $\pm 2 \times 10^{-3} \pm 2$ Hz. More accurate results can be achieved when the Receiver is fitted with a crystal controlled time-base (see para. 2.8.5.).

2.8. Ancillary devices

The following described ancillary devices are available only if requested for inclusion or delivery. Retrofitting of ancillary devices which were mentioned in paras. 2.8.2. to 2.8.6. is possible at any time.

Mounting and alignment instructions are to be found in section 5 MAINTENANCE AND GENERAL INFORMATION.

For accessory orders which are placed after original delivery, the given order numbers should be used for the required items. A compilation of all order numbers also is listed in section 1 TECHNICAL SPECIFICATIONS.

2.8.1. Speaker Facility LDZ-3

The Speaker Facility LDZ-3 enables an easily established connection for speech between both measuring locations used in end-to-end measuring. Moreover, the additionally availalbe speech channel levies no demands upon the system because it is switched into and out-of the same line used for measuring. The Speaker Facility LDZ-3 is assembled in a separate case, but it must be combined with the LDE-3 and the LDS-3 in a common 19" case, having carrying handles mounted on the side. The measuring set in this version - see Fig. 2-5 - has the order number BN 617/20.

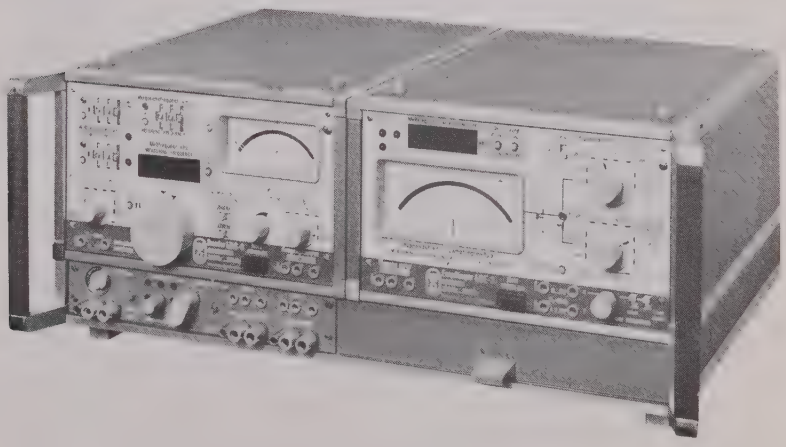


Fig. 2-5 Measuring Set LD-3 with Speaker Facility LDZ-3

The illustrated measuring set is connected to the A.C. power line by means of the power cable at the Speaker Facility. The power line outlets on the back panel of the Speaker Facility feed each of the power connections of the Send Unit and the Receive Unit. However, selecting the line voltage is done at the basic units.

The Speaker Facility in itself does not have a power supply, it receives power from one of the other two Units. Therefore, the cable with the 5 pole AF connector must be connected to Bu 105 on either the Generator LDS-3 or the Receiver LDE-3.

The Speaker Facility LDZ-3 occupies only approx. half of the width of the front panel. In the remaining half, there is allocated storage space for the handbook in a drawer under the Receiver. An additional compartment accessible under both Units is arranged for storage of accessories and the mains power card.

Fig. 2-6 represents the front view of the Speaker Facility, but the storage space is not shown.

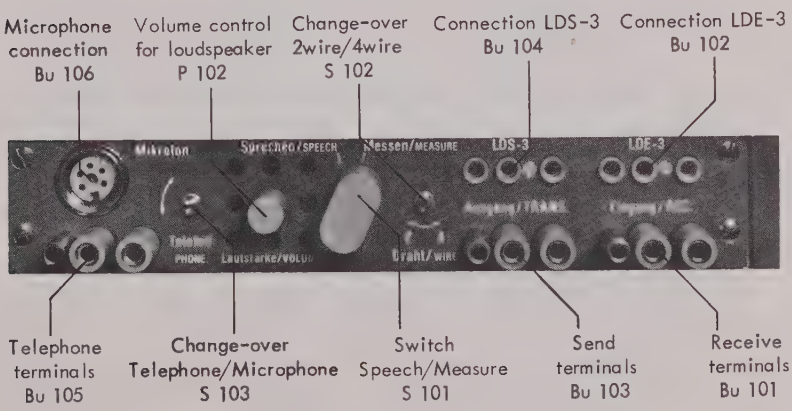


Fig. 2-6 Front view of the Speaker Facility (without storage space)

The Speaker Facility can be used with either two-wire or four-wire circuits. Assembly of the measuring arrangement for end-to-end measuring for the four-wire mode is depicted in Fig. 2-7. Both measuring sets can be used for measuring in either forward or reverse direction; whereby, one Speaker Facility is required at each location.

The 5 pole connector on the cord at the rear of the set is connected to the connector Bu 105 on Receive Unit at each end. With two-wire circuits: for the Measuring Set at location A, only the Generator is operated, and in location B, only the Receiver is operated. In Fig. 2-7, the connections represented as the lower circuit under test are eliminated between location A and location B. In location A, the 5 pole connector on the cord at the rear of the set is plugged into the chassis connector Bu 105 of the Generator Unit. In location B, the cord remains plugged into the connector Bu 105 of the Receiver Unit.

Switch S 102 is used to change-over between two-wire or four-wire operation.

The speech connection is established at the Speaker Facility by connecting a normal type telephone set to the pair of terminals (for two-wire circuits having loop-holding circuits), or a field telephone with inbuilt d.c. source (four-wire circuit), or a microphone (with two or else four-wire connections).

Changing-over from speech to measuring mode is done at switch S 101; moreover, the d.c. loop being held at the time is not interrupted.

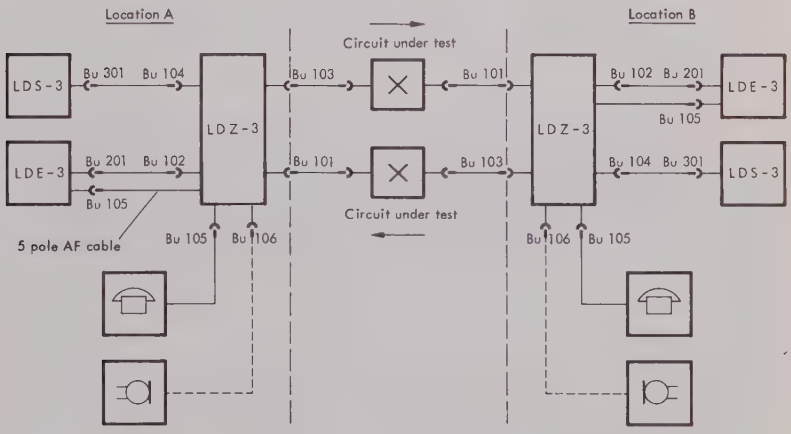


Fig. 2-7 End-to-end measuring on four-wire circuit with Speaker Facility LDZ-3

Through the inbuilt loudspeaker, there is the possibility of again speaking to the opposite end after a measurement has been made. The loudspeaker remains connected

to Send Unit or Receive Unit, but there is no degradation of the measuring process. Volume is varied with potentiometer P 102.

2.8.1.1. Step-by-step instructions for operation of the Speaker Facility LDZ-3

- Connect the equipment according to Fig. 2-7
- S 101 on LDZ-3 set to "SPEECH", S 102 according to the connection at "2" or "4", S 103 in setting "PHONE" or "MIKROFON" according to the connection
- Choose the connection which corresponds to that telephone set connected to the LDZ-3 (or with fixed connected lines and microphone connection, there is direct conversation capability with opposite position), now it is possible to discuss equipment settings with opposite position.
- S 101 in setting "MEASURE", measuring can proceed
- If location A wishes to discuss something with the opposite location, then location A switches S 101 to "SPEECH" and uses the telephone microphone (or a microphone). Location B hears the sound coming in on the loudspeaker at his LDZ-3.
  The same is possible in the opposite direction.
- In order to speak in the opposite direction; the called party must switch his S 101 to "SPEECH". Thereupon, both locations can converse together by means of telephone sets (or else via microphone and loudspeaker).

Also when operating the Speaker Facility with the Measuring Set LD-3, it is possible to use measurement modes, "Retransmission of measured results", (para. 2.6.) and "Remote control of a second Send Unit" (para. 2.8.6.).

2.8.2. Low-pass filter

For suppressing the 16 kHz toll costing pulses and for reducing interference, there is available a low-pass filter with a limit frequency of 10 kHz. The low-pass filter is fitted to the Speaker Facility. The ordering designation for the necessary extra circuit board is :

"Low-pass filter, BN 617/51".

2.8.3. Tone blocking

After the ancillary card "Tone blocking filter, BN 616/11" is added to the Send Unit (Generator LDS-3), there is the possibility of blocking two optionally chosen signalling tones in the frequency range 1.6 to 20 kHz. Thus, two values are available from the group of normally used signalling frequencies.

The facilities for tone blocking prevent the Measuring Frequencies from operating signalling receivers in the transmission system and, therewith, from interrupting the circuit. The response range of the tone blocking filter is:

$$f_{filter} \pm 150 \text{ Hz}$$

The blocking frequency of each inbuilt tone blocking filter is marked on the front panel of the Send Unit. Before measuring, the chosen tone blocking filter is switched in with the corresponding slide switch (S 204 or S 205). When a tone filter is switched in, the blocked frequency should not be manually selected; with swept operation, the blocked frequency is skipped over. Simultaneous switching-in of both filters is permitted if the chosen blocked signalling frequencies plus their response ranges do not cut out too much from the measuring range.

2.8.4. D.C. loop holding circuit for measuring over subscriber's telephone circuit

When measuring over subscriber's telephone circuits, there very often is substitution of the Units in LD-3 for the subscriber's telephone sets. This requires holding the loop while changing ofer from a subscriber's telephone set to the output of the Generator Unit or the Input to the Receive Unit, that is, the d.c. must be interrupted as it flows from the "a" wire to the "b" wire. Therefore, the change-over from telephone set of Send Unit or to input of Receive Unit should include a loop holding circuit. For enabling the Send Unit output or the Receive Unit input to be loaded with the loop holding current, both units must be fitted with the ancillary card "D.C. loop holding circuit, order No. BN 615/14 .

The change-over from subscriber's telephone set to Generator output or to Receiver input is done in either of two ways:

- Operating the Measuring Set without the Speaker Facility LDZ-3

The connection which is to be measured-out is established with the subscriber's set as normally connected. Thereupon, the "a" and "b" conductors of the line are connected to the corresponding contacts of the Send Unit or Receive Unit input :

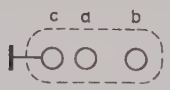


Fig. 2-8
Connector designation of Bu 301
(Send Unit output) and Bu 201 (Receive Unit input)

Due to the change-over necessitating no interruption of current, a corresponding make - before - break change-over should be used. If there is no suitable change-over switch available, then the conductors may be connected together (short-circuited). During the measurements, the loop-holding current flows via the d.c. loop-holding circuit in the Send Unit or Receive Unit.

- Operating the Measuring Set with the Speaker Facility LDZ-3

The subscriber's telephone set is connected to the Speaker Facility LDZ-3. After the circuit is connected, change-over switch S 101 on the LDZ-3 switches the telephone set between Send Unit output or Receive Unit input. For operation of the Speaker Facility LDZ-3, see para. 2.8.1.

If Units are fitted with the d.c. loop holding circuit, then a label showing the max. holding current is affixed over the Generator output or the Receiver input connector: e.g. 600 Ω/100 mA.

2.8.5. Crystal controlled time base

The given accuracy of frequency setting and evaluation as indicated in section 1 TECHNICAL SPECIFICATIONS can be essentially increased through the inclusion of two ancillary cards "Crystal controlled time base (1 MHz Oscillator and Frequency Divider) order No. BN 615/13". When the crystal controlled time base is fitted, the frequency readout error is not greater than $\pm 1 \times 10^{-5}$.

In CCITT Recommendation M. 102, the permitted maximum frequency error is ± 5 Hz for a CF circuit. Therefore, using a Measuring Set LD-3 which is fitted with a crystal controlled time base, it is possible to verify if CF circuits are operated within the limits of max. permitted frequency offset. However, for accurate measurements of frequency offset, measuring equipment designed for that purpose should be used; e.g. the FVM-1 Frequency Shift Meter from Wandel u. Goltermann.

2.8.6. Remote control of level, Measuring Frequency and Reference Frequency

Remote control of a Send Unit (Generator LDS-3) at location B and responding to control of level, Measuring Frequency and Reference Frequency by the operator at location A can be executed with a second Measuring Set LD-3. Thereto, three ancillary cards are required to be fitted in the Measuring Set which is at location B. With remote control, there is the possibility also to measure the circuit in the opposite direction, B to A. The configuration is depicted as follows:

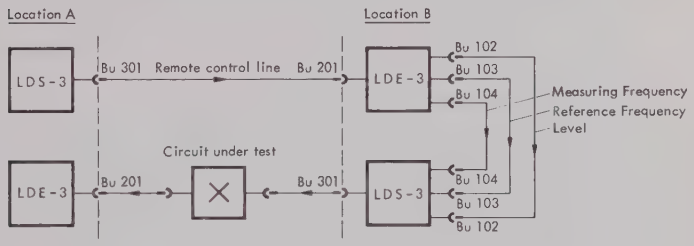


Fig. 2-9 Remote control of a second Send Unit in the direction B to A

The Receive Unit LDE-3 at location B must be fitted with ancillary cards:

"Buffer-store for level remote control, order No. BN 615/11",

"Reference Frequency discriminator, order No. BN 615/12".

In Send Unit LDS-3 at location B, there must be ancillary card

"Measuring Frequency remote control, order No. 616/12".

Connectors Bu 102, Bu 103 and Bu 104 on the back panels of the Send Unit and the Receive Unit at location B are connected together with three BNC cables.

At the Measuring Set location B, for the usual situation there are no other settings required.

Measuring Frequency and Reference Frequency can be set independently of the characteristics of the remote control conductors from location A.

Remote control of level remains unaffected by the frequency response of the remote control conductor because the level in Receive Unit at location B is only sampled during the reference cycle.

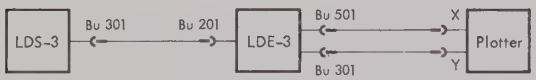
3. TECHNOLOGICAL INSTRUCTIONS

3.1. Explanation and expanded presentation for the technical specifications of para. 1.1.2.

3.1.1. Additional error with variation in Measuring Frequency [A]

As a result of being placed at the input to the receiver, the high-pass filter(which is used for suppressing signalling noises) influences group delay measuring so there is an additional error with variation in Measuring Frequency. This error becomes larger when the Measuring Frequency is reduced. The warranted values given in para. 1.1.2. can be re-checked with closed circuit measurements by the user. Thus, he obtains an error correcting curve for his Measuring Set, and consequently knowing the error for each group delay measurement result, he does not need to take into account the warrented values.

The measuring configuration of Fig. 3-1 is setup for plotting the group delay response with variation in Measuring Frequency.



Reference Frequency: 1.8 kHz
Send level: 0 dBm
Sweep rate: 10 Hz/s

Measuring range for $\Delta\tau g$: ± 0.1 ms

Fig. 3-1 Measuring configuration for plotting the group delay response with variation in Measuring Frequency.

Due to the error remaining constant for Measuring Frequencies over 1 kHz, the sweep range of 200 Hz to 2 kHz is sufficient. When a high send level is injected, then there is a large signal-to-noise ratio and therewith an unequivocal run of measured results. The typical curve for group delay/frequency distortion of a Measuring Set LD-3 for the given conditions is plotted in Fig. 3-2.

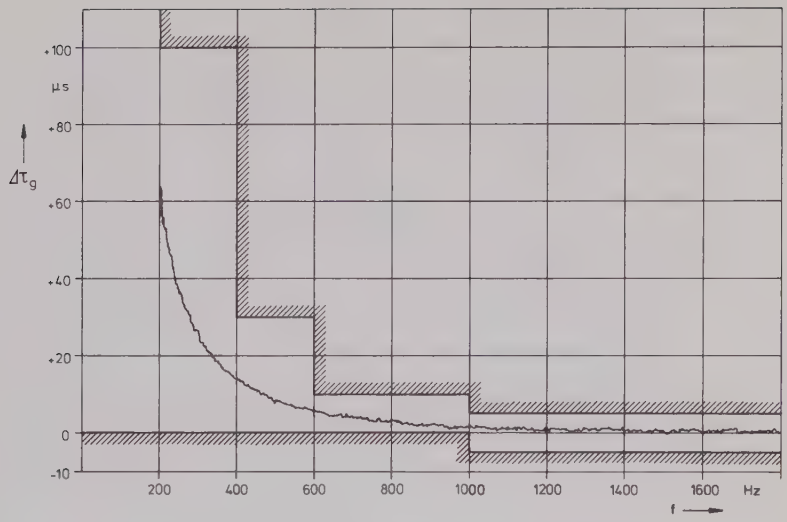


Fig. 3-2 Typical group delay/frequency distortion of a Measuring Set L D - 3

3.1.2. Additional error [B]

For supplementing section 1 TECHNICAL SPECIFICATIONS, the values as given for the additional error in Receiver introduced by attenuation difference between Reference Carrier and Measuring Carrier (Additional error [B] in para. 1.1.2.) again are given in an expanded and more detailed form. Thus, the user also in cases of extremely large differences, can take into account that there is a probable group delay error, or he can select measuring conditions for holding the error to a small value.

B : From additional error introduced by attenuation difference between Reference Carrier and Measuring Carrier

Level range of Reference Carrier . . . . . - 40 to + 10 dBm

Frequency range of Reference Carrier . . . . . 400 Hz to 20 kHz

at attenuation difference	Level range of Measuring Carrier -40 to +10 dBm			-50 to +10 dBm		
	I	II	III	I	II	III
10 dB	≦± 3µs			≦±10µs		
20 dB	≦± 5µs			≦±15µs		
30 dB	≦±10µs			≦±20µs		
40 dB	≦±50µs	≦±15µs	≦± 5µs	≦±55µs	≦±25µs	≦±15µs
50 dB	≦±400µs	≦±100µs	≦±10µs	≦±420µs	≦±120µs	≦±20µs

Column I: No restrictions on boundary conditions

Column II: Level of the Reference Carrier > level of the Measuring Carrier

Column III: Level of the Reference Carrier > level of the Measuring Carrier and frequency range of the Reference Carrier 1.8 to 20 kHz

The group delay errors for small attenuation differences (up to 30 dB) only appear with full magnitude when one of the two carrier levels (Reference Carrier or Measuring Carrier) lies at the lower limit of the permissible level range.
If it is possible that the input level to the Receiver be increased so far that the smaller of the two carrier levels is for instance, 10 dB over the lower limit of the permissible level range, then the group delay error is reduced by a factor of 3.
This is valid for all given values up to 30 dB attenuation difference.

With group delay errors for attenuation differences > 30 dB, very large values (column I) can occur. This is caused by the Receiver having a step response which must accept every change-over of carrier frequency. This error is especially noticeable as being introduced at low frequencies because the signal, at the point in time of the change-over, contains a large d.c. voltage component (each according to the sample). As a consequence, the larger the attenuation difference compared to the succeeding smaller carrier level, then the stronger the affect of the step response on this d.c. voltage component influencing the group delay error.
However, if there are restrictions on the boundary conditions, as is often the case in practice, then essentially better values are obtained (column II and III). The restrictions are defined in the explanation to the table.

3.2. Measurements referred to a standard with the aid of a relay change-over switch

In addition to the main application of the Measuring Set, measuring group delay and attenuation/frequency distortion according to the carrier change-over method, it also is possible with the use of a suitable relay change-over switch to apply the measurement mode, "Test object/Reference object".

If the reference object is a short cable, that is, with negligible group delay and attenuation, then it is possible to measure absolute group delay and attenuation.

With measurements referred to a standard, the carrier change-over is switched off at the Generator. This is done with switch S 402 of the Generator being placed in position "I" (indicator lamp Gl 202 blinks!). The change-over between test object and reference object with the clock rate of 4.167 Hz is done by the relay change-over switch. The necessary change-over frequency for triggering the relay change-over switch can be obtained from either Generator or Receiver at point 4 of the 5 pin AF connector Bu 105.

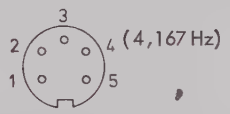


Fig. 3-3
Connector Bu 105
(seen from terminal side)

The circuit setup for operating in mode "Test object/Reference object" is as follows:

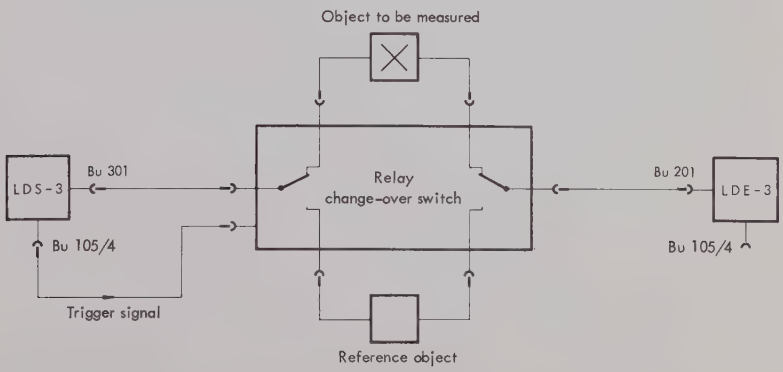


Fig. 3-4 Circuit setup for measurements referred to a standard

4. APPLICATIONS AND CHARACTERISTICS

4.1. Measurement principle

The complex transmission quantity $\underline{g}$ of any optionally chosen two port network can be written as the expression

$$\underline{g} = a(\omega) + jb(\omega)$$

Therewith, $a(\omega)$ represents the attenuation/frequency distortion behavior and $b(\omega)$ represents the group delay behavior.

Due to telephone circuits being intended exclusively for transmission of speech, the corresponding transmission sections are designed for such requirements only that the speech be intelligible. The human ear judges this intelligibility according to the spectral energy distribution of the incoming signal, thus, the signal shape is of no consequence. However, since the transmission of the spectral energy distribution of any random signal is affected by the attenuation behavior of the section, and the signal shape also is influenced by phase response, the frequency relationship of a telephone channel was sufficiently described with accuracy by giving the attenuation/frequency distortion curve. But this is not satisfactory for the use of telephone channels to carry data information. In this case, the signal at the input to the send modulator is made up from individual rectangular pulses which should be presented with as little change as possible to the receive modulator.

However, this is only assured when the transient response of the transmission system is considered not only for attenuation but also for phase behavior.

Phase measuring over telephone lines is accompanied by difficulties because the input voltage to a circuit is not available as a reference voltage at the output of the circuit additionally, a small difference of carrier frequencies can cause a frequency shift (up to 10 Hz) between input and output of the carrier frequency system. This frequency shift can result in an incorrect measurement. For this reason, the criterion for the phase behavior is not the phase in itself, but, instead, the derivative of the circuit phase shift (in radians) with respect to frequency (radians per second); i.e., $\Delta\tau_g$.

The basis for obtaining the group delay/frequency distortion is the Nyquist principle with which the phase shift is determined. With this method, the time is measured for that required to propagate a change in the envelope of a signal through the object under test. This phase shift is, with sufficiently low modulation frequency, a direct measure of the group delay distortion of an object under test. By means of varying the carrier frequency, the group delay variations with frequency at the frequencies of interest can be obtained.

In the original form of this measuring method, demodulating the input voltage as well as the output voltage provided two modulation voltages and the phase differences between both could be measured. This phase difference is proportional to the group delay distortion of the object under test. In practical applications, however, the main interest is in group delay difference; that is, changes in group delay with frequency compared with the phase delay at a mean value of transmission frequency. These variations usually are an order of magnitude smaller than the absolute group delay distortion, so the changes in group delay distortion caused by forming differences of large magnitudes are variations which are measured with reduced accuracy. Furthermore, end-to-end measuring between a generator separated by distance from a receiver is not possible to do without additional equipment.

These disadvantages are prevented from occurring when the Measuring Set LD - 3 is used because it makes use of another method. The simplified block diagram illustrates the operating principle:

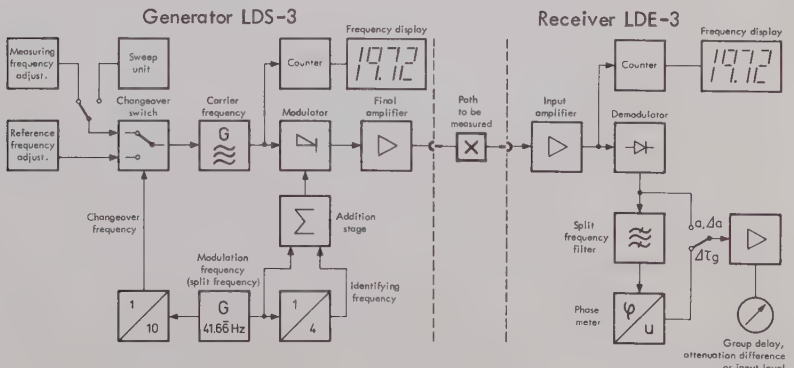


Fig. 4-1 Simplified block diagram of Measuring Set LD-3

Two carrier frequencies are produced by the Send Unit and are periodically sampled at a frequency of 4.167 Hz. These are continuously amplitude modulated with a Modulation Frequency of 41.67 Hz . One of the two carriers is varied in the frequency range of interest (Measuring Frequency) whereas the other is fixed at a definite frequency (Reference Frequency). For identifying the reference clock cycle, there is an additional modulation of the Reference Carrier during the last 20% of the reference time, and this in known as the Identifying Frequency of 166.67 Hz.
If the Measuring Signal is routed to an object under test and there is a difference in group delay responses between the two carrier frequencies, then the envelopes of the signals exhibit a phase jump at the output of the object under test.
In the Receiver, during every reference time, there is the periodic alignment to establish zero phase shift.
During the measuring time, the phase meter acquires a result which corresponds to the group delay difference between the Measuring Frequency and the Reference Frequency. As a result of the periodically repeated alignment for zero phase shift, both the drift and the instability with time are prevented. Corresponding to the difference in attenuation response of the object under test, the Measuring Signal and the Reference Signal are at different amplitudes at the output from the object under test. Indication of the result of an evaluation is readout so the attenuation difference is referred to the Reference Signal.

4.2. Send Unit (Generator LDS-3)

The Send Unit produces a fixed and defined signal as recommended in CCITT Recommendation O.81. The send signal is again illustrated in Fig. 4-2. In addition to the send signal Fig. 4-2 contains individual signals derived from the send signal. The method by which the Send Unit functions is explained by the fold-out block diagram at the end of the handbook. In essence, there are 4 modular units:

- Carrier frequency generator and control (5)
- Modulation frequency generator (4) (auxiliary frequency generator)
- Modulator and output amplifier (3)
- Frequency counter (6)

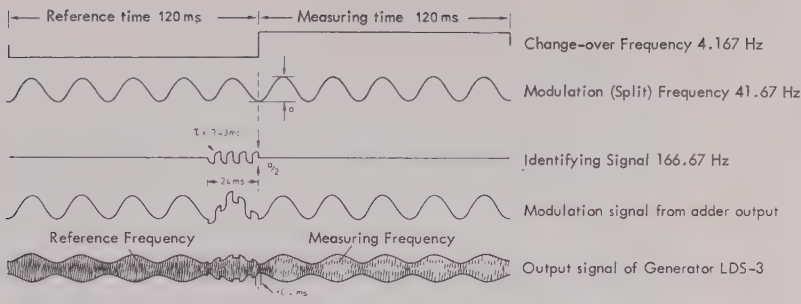


Fig. 4-2 Signal diagram of Generator LDS-3

4.2.1. Carrier frequency generator (5)

The main item in the carrier frequency generator (5) is the triangular wave generator (voltage-to-frequency converter). A sinusoidal wave shaper circuit which follows takes the periodic triangular wave and converts it to a periodic sinusoidal wave. Two voltages produced by d.c. voltage stabilizers are supplied to the triangular wave generator for converting to measuring carrier and reference carrier frequencies. Both d.c. voltages are applied to the carrier frequency change-over switch which alternately changes at a frequency of 4.167 Hz and is fed to the triangular wave generator. The automatic control circuit of the d.c. voltage stabilizer for the setting of the Measuring Frequency can be separated by means of a auto. control circuit switch. At the carrier frequency change-over switch these d.c. voltages are routed to set the upper or lower sweep limits or once more to set the Reference Frequency. The values for the d.c. voltage are preselected or set by means of a "resistance program".

The Reference Frequency plus the upper and lower sweep limits are set-up with the thumb-wheel switches S 203, S 202 and S 201; the Measuring Frequency is set with potentiometer P 503.

In the sweep mode, the auto. control switch is completely inoperative. A clock frequency of 4.167 Hz is provided through switch S 505, and the charging pulses with adjustable width are supplied via the charging circuit to the integrator. According to the direction of charge, the output voltage of the integrator can be

adjusted in steps for both rise and fall. When the output voltage of the integrator attains the respective preselected value of voltage for the upper or lower sweep limit, then the sweep either is switched off (with single-shot sweep) or is reversed in direction (with continuous sweep).

4.2.2. Modulation frequency generator (4)

In the modular unit, modulation frequency generator (4), the local oscillator generates the Modulation Frequency of f = 41.67 Hz. By means of frequency division and multiplication, the phase-locked derivatives result in the Change-over Frequency 4.167, the Identifying Signal 166.67 Hz and the gate time 100 ms for the frequency counter. In the adder, at the last fifth of the reference time, after being rotated 90° the Modulation Frequency is added to the Identifying Frequency.

4.2.3. Modulator and output stage (3)

The amplitude modulation of the carrier oscillation is done in the modular unit, modulator and output stage (3). In modulator I, the modulation signal has superimposed on it a d.c. which is adjustable by means of potentiometer P 307 whereby the modulating alternating current amplitude is maintained at the chosen ratio (to the d.c.) of 1:2.5 (depth of modulation, m = 0.4). The mixer current is routed to Modulator II where the typical amplitude modulation of the carrier signal results. D.C. and modulating a.c. are suppressed at the output of modulator II, and only the output from modulator II appears. This is the carrier oscillation f_T with both side bands $f_T - f_M$ and $f_T + f_M$.

Modulator II output is fed into the coarse level attenuator S 301 and the output stage which provides the output power. The output transformer provides galvanic separation from the equipment circuits plus a balanced and floating output. The object under test is matched without any return loss by means of the output impedance matching network.

4.2.4. Frequency counter (6)

The four decade digital frequency readout operates with the aid of the modular unit, frequency counter (6).

The frequency counter is gated by the 100 ms gate-time derived from the Modulation

Frequency and consequently is available only during the measuring cycle; thus displayed only during this time is the frequency generated by the triangular wave generator. In the ×10 frequency multiplier, the Measuring Frequency first is multiplied by 10 before being routed to the frequency counter. The push button switch S 601 enables raising the resolution of the frequency readout.
Accuracy of the counter depends on the modulation frequency oscillator. For achieving higher accuracy, a crystal controlled time base (BN 615/13) can be fitted as an option if requested.

4.3. Receive Unit (Receiver LDE-3)

The Receive Unit LDE-3 contains the circuitry which evaluates the phase and attenuation jump of the modulation envelope. This jump is due to the response of the object under test.
The receiver is divided into four main groups (see fold-out block diagram):

- Input amplifier (2)
- Evaluation circuit (4)
- Display amplifier (3)
- Frequency evaluation (5)

4.3.1. Input amplifier (2)

The input to the Receiver is balanced and floating. Combined with the carrier demodulator, the input amplifier forms a unit . It operates without an input attenuator and covers the complete receive level range from - 50 to + 10 dBm.
The carrier component which after demodulation remains a double frequency is suppressed in the carrier frequency filter. At the output of the filter, there is a d.c. proportional to the carrier level and the d.c. has modulation superimposed on it (split frequency and identifying signal). Following that is the logarithmic amplifier which forms the carrier current into a voltage (1 V/10 dB) which is proportional to the logarithm of the input level.

4.3.2. Evaluation circuit (4)

In the evaluation circuit (4), there is separation of the functions, the measuring of group delay, level and attenuation. By means of the logarithmic amplifier, the

modulation amplitude is independent of the input level. It is selectively amplified and limited in the split frequency filter. A jump in phase is contained in the rectangular-wave shaped voltage at the output of the split frequency filter, and this phase jump is caused by the object under test. The rectangular wave is used to synchronize the multivibrator which generates the split frequency pulses. With an unmodulated input signal (operation as level meter) this multivibrator is free-running.
In the identifying signal channel, the output from the logarithmic amplifier is used to produce an identifying pulse which first starts the 198 ms monostable. After this time interval, the pulse stage is enabled. The succeeding AND gate generates a setting pulse which determines the positions of the measuring and reference cycles and therewith the clock for all other control signals.
The d.c. voltage corresponding to the mean value of the carrier level at the output of the 41.67 Hz band-stop filter is routed through a 13 Hz low pass filter. Thereupon the remaining modulation components (41.67 Hz and 166.67 Hz) are sufficiently rejected for the measured value evaluation in the display amplifier.

4.3.3. Display amplifier ③

The display amplifier weights the offered signals and delivers them to the display. Therefore only the pertinent evaluation of a measured result - group delay distortion, attenuation distortion or level - is possible. The display buffer-store accepts the measured result when the sampling signal comes from the display amplifier. The meter voltage and the "Y" axis output voltage are a steady-state voltage which corresponds to the measured result.

4.3.3.1. Measuring group delay differences

The 100 ms monostable and the 9 ms or 4 ms/14 ms delay networks are designed for the time intervals needed in group delay measuring. To begin either the measuring cycle or reference cycle, the 100 ms monostable is started. After the 100 ms has elapsed, the 9 ms delay network is triggered. If the split frequency signal has no phase jump ($\Delta\tau_g = 0$ ms), then the total elapsed time is 11 ms from the run down of the 109 ms to the next triggering of the 100 ms monostable. This is valid not only in the measuring cycle but also in the reference cycle. However, if the split frequency signal does contain a phase jump, then the elapsed times are of unequal

magnitudes in the measuring and reference cycles the renewed trigger for the 100 ms monostable. The clock generator derives from these elapsed times the signals "charge" and "recharge". In the display amplifier, the signals "charge" and "discharge" are used as two constant currents to furnish bidirectional charges for a capacitor. With a group delay difference of 0 ms, the capacitor again has the same condition of charge after discharge as at the beginning of the charging process. When group delay differences are present, then of course there are differences in charging and discharging times, and the capacitor has at the end - according to each algebraic sign of the group delay difference - a positive or negative charge. The charge corresponds to the measured result.

After the measured result has been accepted in the display buffer-store during the sampling time, the capacitor again is discharged. For changing the measuring range, the capacity of the capacitor is electronically changed. The maximum possible measuring range is ± 10 ms. Moreover, the inbuilt group delay offset of + 5 ms (switchable with S 302) permits extending the measuring range to + 15 ms. This is achieved by changing the time intervals in the 9 ms delay network (4 ms delay in reference cycle and 14 ms delay in measuring cycle).

4.3.3.2. Measuring of attenuation differences

The display amplifier contains a d.c. voltage corresponding to the input level having been evaluated in (4), the evaluation circuit.

At the beginning of the reference cycle, the display amplifier is fixed to the measuring level by a clamping pulse. With the following sampling pulse, it accepts the reference level. The display amplifier forms the difference from measuring level and reference level, and thus the attenuation referred to the reference level is fed to the display. The measuring range switch S 304 varies the display amplification.

4.3.3.3. Measuring the receive level

The level measurement not only with normal operation is a change-over between Measuring Carrier and Reference Carrier but also is possible with unmodulated input signals. For normal operation of the Measuring Set, the level of the measuring carrier is displayed.

Simultaneously with the clamping signal from the clock generator, the signal "set zero" is routed to the display amplifier. With this signal, the display amplifier acquires its reference point for the succeeding formation of a difference. This reference point corresponds to a definite d.c. voltage according to each set-up level measuring range.

During the sampling process, the display amplifier accepts a d.c. voltage corresponding to the measuring level from the evaluation circuit (4), and the display amplifier forms the difference to the reference point. The possible difference provides a reading of ± 10 dBm; the reference point can be varied in 10 dBm steps from - 40 to 0 dBm. If the level of the reference carrier appears at the display, then the signals", clamp", "sample" and "set zero" are placed into the other cycle.

4.3.4. Frequency evaluation (5)

The frequency evaluation (5) enables the frequency readout of Measuring and Reference Frequencies with carrier change-over operation, and as well of the various other input signals. If the push button S 301 is not depressed, then the display is the readout for the Measuring Frequency. A portion of the input signal is routed to an automatic control amplifier which produces a constant value and converts it to a rectangular signal. The following differential flip-flop compares the frequency output ($f_{nominal}$) from the auto. control amp. with the frequency (f_{actual}) from an internal multivibrator.

The readout signals from the differential flip-flop convert a charging current into a d.c. voltage which changes the frequency of the multivibrator until the condition $f_{actual} = 10 \times f_{nominal}$ is achieved. The frequency f_{actual} of the multivibrator causes the frequency counter (with readout buffer-store and decoder) to display the frequency; additionelly, it provides at the output of a discriminator a frequency proportional d.c. voltage for the X deflection of an X-Y plotter.

Synchronization of the internal frequency generator with that measuring frequency which had been applied to the input is done in the measuring cycle. The gate time of 100 ms for the frequency counter occurs in the reference cycle, so the measuring frequency is readout during the reference cycle. Gating time is delivered by the 100 ms monostable of the evaluation circuit (4). For purposes of producing a more exact frequency readout, the gate time can be produced by a crystal controlled time-base (BN 615/13) which is available as an option.

5. MAINTENANCE AND ADDITIONAL INFORMATION

5.1. Checking the functions of the Measuring Set

For a fast determination to see if the Measuring Set is ready for operation, e.g. after a long period of storage in a measuring set store house, a short test can be made. This test also is described in para. 2.5.1.1.

It is done as follows:

- Measuring Set connected to a.c. power line
- Power switch ON both Send Unit and Receive Unit
- Connection between Send Unit output Bu 301 and Receive Unit input Bu 201
- Set the send level 0dBm with switch S 301 and potentiometer P 307
- Set the Measuring Frequency and the Reference Frequency at 1.8 kHz
- Toggle switch S 303 on Receive Unit to upper position
- Measuring range switch for group delay distortion S 305 set at ± 1 ms
- Depress push button S 401 "TEST" at Send Unit
- Meter on Receive Unit must read at approx. ± 1 ms
- Toggle switch S 303 to lower position
- Measuring range switch for attenuation distortion S 304 at ± 1 dB
- Depress push button S 401 "TEST" at Send Unit
- Meter on Receive Unit must read at approx. + 1 dB

5.2. Removing the equipment panels

Note: Remove a.c. power plug before opening equipment for maintenance service. Base plate, intermediate base plate, cover and side panels are fastened to the main frame by means of tension screws on the back panels of the Measuring Set. All of the metal panels can be removed by pulling backwards after unscrewing the corresponding tensioning screws. The side panels of the Speaker Facility are each fastened with two slotted screws.

5.3. Modifications, function checks and alignment of the ancillary devices

Paragraphs 5.3.1. to 5.3.7. afford the user, himself, opportunities to install ancillary devices to modify the pertinent equipments of the Measuring Set-up. Information is given for checking the functions and if necessary, for alignment of the devices. Necessary test equipment should be available in any service department. The test equipment needed for an operation is specially mentioned in each paragraph.

Extreme care should be taken to prevent damaging components on circuit boards being added to equipments, and of course, the equipment being modified should be protected from being damaged during the modification process.

Equipment should be switched ON and warmed up for 10 minutes before checking the functions or alignments of added circuits. All values given in the paragraphs for checking functions and alignments are for room temperature.

Printed circuit boards are identified with designations such as e.g. 616-L or 616-7010 or also with codes. These designations are provided also in the following paragraphs. Typical identifying numbers are given for each circuit board.

5.3.1. Tone blocking filter, BN 616/11

The tone blocking filter is an ancillary device for the Generator LDS-3. Designations for the subsequently delivered printed circuit boards are: 616-L; 616-7010.--

Modification:

- Remove cover from Generator
- Printed circuit board "Tone blocking filter" should be inserted into the contact strip located on the internal basic circuit board, the free end of the insulated cable shouod be connected to the AMP pin which projects from the rear vertical circuit board
- Printed circuit board is fastened with four screws.

Checking out functions of the insertion frequency (jump frequency) of the tone blocking filter:

No test equipment is needed for checking the functions.

Switches S 204 and S 205 on the front panel are used to switch in or out two individual tone blocking filters at definite frequencies determined when the filters are ordered from the factory.

- A tone blocking frequency filter is switched in with switch S 204 (low frequency) or with S 205 (higher frequency)

- Measuring Frequency tuning changed-over to fine drive mechanism and tuned in the direction of higher frequencies

- At the Measuring Frequency,

  $f_{M1} = f_{filter}$ - 150 Hz to 180 Hz, this must jump to:

  $f_{M2} = f_{filter}$ + 150 Hz to 180 Hz

Example: Rated frequency of the tone blocking filter, f_{filter} = 2280 Hz

f_{M1} = 2280 - 150 Hz to 180 Hz = 2100 Hz to 2130 Hz

f_{M2} = 2280 + 150 Hz to 180 Hz = 2430 Hz to 2460 Hz

i.e. the Measuring Frequency must jump from 2100 Hz to 2130 Hz to 2430 Hz to 2460 Hz.

- Repeat the check for other tone blocking filter

  If the insertion frequency for a tone blocking filter lies outside of the range to be filtered, f_{filter} - 150 Hz to 180 Hz, then a new alignment should be done.

Alignment of insertion frequency (jump frequency) of the tone blocking filter:

- Switch off TONE BLOCKING (S 204 and S 205 in positions OFF)

- Set Measuring Frequency to $f_M = f_{filter}$ - 150 Hz (e.g. f = 2280 Hz - 150 Hz = 2130 Hz)

- Use either switch, S 204 or S 205, to switch ON the pertinent tone blocking filter

- Alignment potentiometers P 1101 (coordinated with switch S 205) or P 1102 (coordinated with switch S 204) are used to set the insertion frequency (jump fre-

quency) $f = f_{filter} - 150$ Hz. These pots. are located on the tone blocking filter printed circuit board.

Due to the insertion frequency having hysteresis, the insertion frequency should be set by counter-clockwise rotation of the potentiometer. Therefore, if the insertion frequency is more than 180 Hz below the rated frequency of the tone blocking filter, the pertinent alignment potentiometer should be first rotated fully clockwise and then by rotating it counter-clockwise, the correct insertion frequency can be set-up.

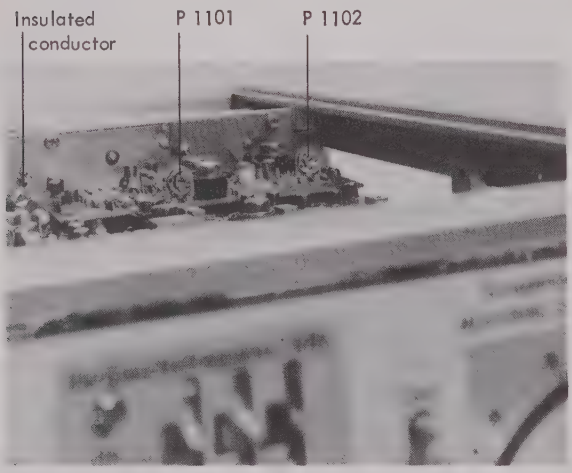


Fig. 5-1

Positions of alignment potentiometers on the printed circuit board "Tone blocking filter"

- Alignment procedure, when necessary, repeated for the other tone blocking filters

- Checking procedure, as previously described, should be gone through

- After checking and aligning, replace cover on the equipment.

Information: The tone blocking filters needed by the customer should be ordered when ordering the equipments. The customer will find it impossible to subsequently change band-stop frequencies.

5.3.2. Measuring Frequency remote control, BN 616/12

The printed circuit board "Measuring Frequency remote control" should be added to the Generator LDS-3. The designation of the subsequently delivered circuit board is: 616-M; 616-7011.--

Modification:

- Remove bottom panel from Generator
- Printed circuit board "Measuring Frequency remote control" should be inserted into projecting contacts and fastened with 4 screws
- Replace bottom panel.

Checking the functions:

Necessary test equipment: 1each Receiver LDE-3

- With an inbuilt printed circuit board "Measuring Frequency remote control" but no established remote control connection between LDS-3 and LDE-3, there should be tuning capability at the Measuring Frequency from the Generator.
- Connect remote control cable between connectors Bu 104 of LDS-3 and LDE-3, the tuning function may not operate at the LDS-3
- Switch S 308 in setting "ADJUST" on Receiver LDE-3
- Potentiometer P 502 adjusted for frequency at Receiver of e.g. f = (1) 0.000 kHz. The frequency readout at the Generator must display the same value f = (1) 0.000 kHz ± 4 Hz
  If the nominal value f = 10 kHz ± 4 Hz can not be obtained, then the following measurements and alignment are required.

Alignment:

Required test equipment: 1 each Receiver LDE-3

1 each frequency counter having period measurement capability e.g. FZ-4 from Wandel u. Goltermann.

- Remove connection at connectors Bu 104 or remote control between LDS-3 and LDE-3
- Connect frequency counter to connector Bu 105 on the back panel of the Generator (Point 4 to point 1 (⊥).

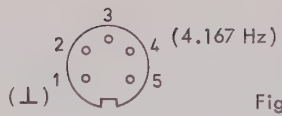


Fig. 5-2 Connector Bu 105, seen from contact side

Reading on frequency counter 240 000 µs ± 200 µs (LDS-3 without crystal controlled time base)

- If the readout is not within the tolerance, then with potentiometer P 401, there should be alignment to the nominal value
  (After the left side panel is removed, potentiometer P 401 is accessible. See Fig. 5-3).

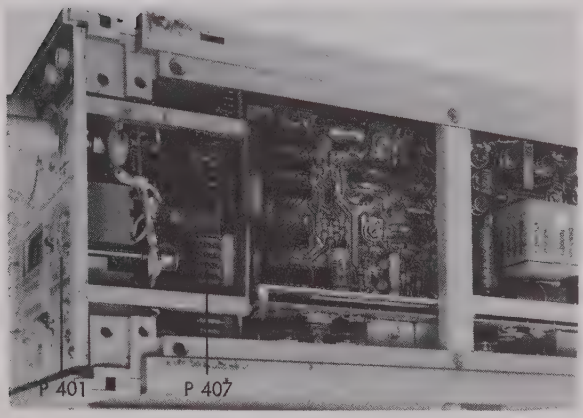


Fig. 5-3
Locations of potentiometers P 401 and P 407

- Repeat "Checking the functions" as previously explained

- If the deviation remains as being too large, then connect the frequency counter at Generator output Bu 301, and disconnect the remote control connection to the Receiver. At the frequency counter, the Measuring Frequency should be set to 10 kHz. The frequency readout of the Generator must now indicate the same frequency as that of the frequency counter, (10 kHz ± 2 Hz)

- If this requirement is not met, then potentiometer P 407, gate time, (see Fig. 5-3) is used to adjust the Generator frequency readout to be identical to that of the frequency counter readout

- Now repeat "Checking the functions" (see previous para.). If the deviation still is too large, then the Receiver must be checked-out for correct functioning

- Testing of Receiver, possibilities: Disconnect remote control connection between Generator and Receiver, and connect an oscilloscope to connector Bu 104 at the Receiver (e.g. an OS-1 from Wandel u. Goltermann)

- Switch S 308 (LDE-3) in position ADJUST, and potentiometer P 502 is used to set a frequency of 20 000 kHz

- At connector Bu 104, there should be pulses having a pulse repetition frequency of 200 kHz and a pulse width of approx. 700 ns, the peak-to-peak voltage of the pulse should be 3.8 V.

If the Receiver fulfills these requirements, then the fault is at the printed circuit board "Measuring Frequency remote control", and the repair should be done at our service facilities.

5.3.3. Buffer-store for level remote control, BN 615/11

Printed circuit board "Buffer-store for level remote control" is to added within the Receiver LDE-3.

The designation of the subsequently delivered circuit board is: 615 1; 615-7008.--

Modification:

- Remove right side panel (seen from the front)

- Printed circuit board "Buffer-store for level remote control" is inserted into the contacts located on the right portion of the basic printed circuit board. Three screws fasten it in position.

Checking and aligning:

Required test equipment: 2 each Generators LDS-3

- Assemble the following configuration

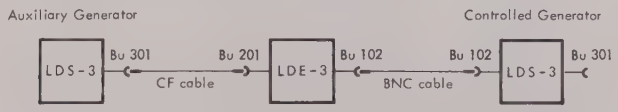


Fig. 5-4 Configuration for checking remote control of level

- At the auxiliary Generator, switch S 402 is placed in position "I" (continuous with modulation)

- Send level auxiliary Generator is adjusted so Receiver indicates exactly 0 dBm

- Now test to determine if, at controlled Generator, the meter reading is at 0 dBm when its coarse level switch S 301 is in position "0 dBm"

- If that is not the case, then adjust P 1102 (500 Ω), located at the centre of the internal circuit board, so the meter reading is at 0 dBm

- Coarse level switch S 301 of the auxiliary Generator is switched to - 20 dBm, and then meter of controlled Generator should give reading of - 20 dBm

- After checking and aligning configuration, replace right side panel on Receiver.

5.3.4. Reference Frequency discriminator, BN 615/12

Printed circuit board "Reference Frequency discriminator" should be added within the Receiver LDE-3.

The designation of the subsequently added circuit board is: 615-K; 615-7009.--

Modification:

- Remote left side panel (seen from front)

- Printed circuit board "Reference Frequency discriminator" inserted into the contacts on basic board and is fastened into position by means of three screws.

Checking and aligning:

Required test equipment: 2 each Generators LDS-3

- Assemble the following configuration

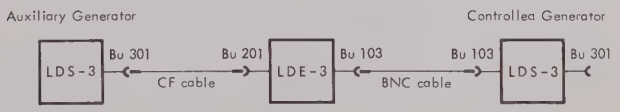


Fig. 5-5 Configuration for checking the remote control of Reference Frequency

- At the auxiliary Generator, switch S 402 is placed in position II (continuous no modulation)

- Send level of auxiliary Generator adjusted to 0 dBm

- Switch S 505 on auxiliary Generator adjusted for SWEEP RATE in single-shot sweep, e.g. 10 Hz/s⌒. Upper sweep limit set to 19.9 kHz, and with potentiometer P 201.2 align to 20 kHz ± 5 Hz
  Lower sweep limit set or aligned to 0.4 kHz ± 2 Hz

- At f = 20 kHz (upper sweep limit on auxiliary Generator) there should be 20 kHz indicated on the controlled Generator when S 501 (Reference Frequency) and S 601 (decimal point) are depresses. If necessary, potentiometer P 1202 (250 Ω), on the right side of the added-in circuit board in the Receiver, should be adjusted so reading is correct

- Furthermore, at f = 0.4 kHz (lower sweep limit of auxiliary Generator), if necessary, potentiometer P 1201 (5 kΩ), on the added-in circuit board in the Receiver should be trimmed to produce reading of 0.4 kHz

- After checking and aligning configuration, replace left side panel on Receiver.

5.3.5. Crystal controlled time base, BN 615/13

For both Sender LDS-3 and Receiver LDE-3, the crystal controlled time base consists of the printed circuit boards "1 MHz Crystal oscillator" and "Frequency divider".

The designations of the circuit boards are:

1 MHz Crystal oscillator:	615-L; 615-7010.--
Frequency divider:	615-M; 615-7011.--

Modification:

There is no difference between modifying the Receiver or the Generator for the crystal controlled time base.

- Remove bottom plate and left and right panels

- The vertical frame pieces at the front of case where the folding handles are fastened are loosened by means of the removal of two slotted screws per frame piece

- Place equipment with front panel upwards

- Withdraw equipment chassis including front panel (use handles to pull-out), see Fig. 5-6

- Within the interior of the equipment chassis, which is accessible from the rear, there is a plugged-in card. This should be pulled-out.

- The metallized covers of both boxes should be gently pried off with a screw driver

- Plug-in card arranged so the plug-in contact comb points to the left

- Insert printed circuit board "Frequency divider" in the left box and the printed circuit board "1 MHz Crystal oscillator" in the right box, and each should be fastened with four screws. Replace covers on boxes. Re-insert plug-in card.

- Pick up equipment chassis at folding handles, and from above the case, slowly guide chassis back to original place. When doing this, note that the metal chassis slides along the white plastic guide rails, furthermore, observe that the long shaft for a.c. power switch is in proper position, see Fig. 5-6.

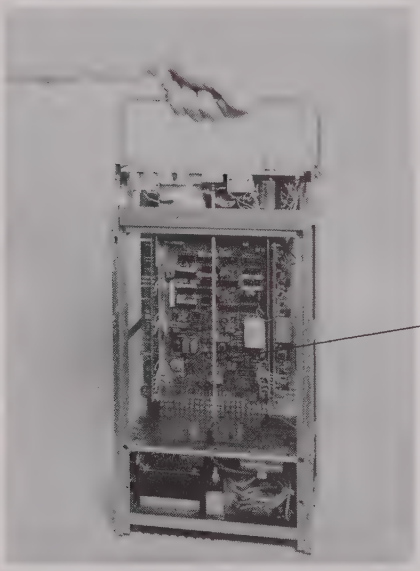


Fig. 5-6
Removal of
equipment chassis

- Refasten vertical frame pieces with slotted screws

- Check the functions after addition of crystal controlled time base

Checking functions after addition of crystal controlled time base:

A subsequent alignment, insofar as where the following given error limits have been violated, is possible only after removal of the plug-in card with circuit boards "1 MHz Crystal oscillator" and "Frequency divider".

Generator LDS-3:

Required test equipment: 1 each frequency counter having period measurement capability e.g. FZ-4 from Wandel u. Goltermann

- Connect frequency counter to connector Bu 105 on the back panel of the Generator (point 4 to point 1(⊥)). For connector arrangement of Bu 105 see Fig. 2-2, Reading on frequency counter: 240 000 µs ± 2.4 µs.

Receiver LDE-3:

For checking-out functions of the Receiver, the necessary measurement signal is:

level = approx. 0 dBm, frequency = 10 kHz ± 0.01 Hz

(e.g. Generator LDS-3 (S 402 in position "II", continuous without modulation and with frequency verification by means of a counter)

- Settings on Receiver: S 304 at "LEVEL 0 dBm", S 307 at "FAST" and S 308 in "OFF" position

- Measurement signal is connected to the input of the Receiver, and frequency read-out is read for :

Nominal value: 10.00 kHz

- Therupon, depress push button S 502 for decimal point shift for

Nominal value: (1) 0.000 kHz ± 1 Hz

The last digit may jump by ± 1 Hz.

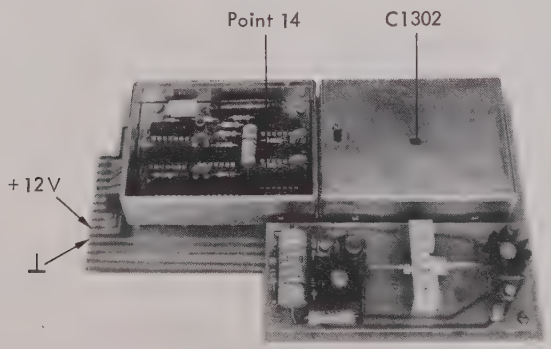


Fig. 5-7 Plug-in card with crystal controlled time base and d.c. loop holding circuit

Alignment of crystal controlled time base:

Required test equipment: 1 each d.c. voltage supply 12 V
1 each oscilloscope
1 each 1 MHz frequency standard ($\frac{\Delta f}{f} \leqq 1 \times 10^{-6}$)

- Remove plug-in card from equipment and prepare according to Fig. 5-7.

- 1 MHz signal (V_{pp} = 5 V) at point 14 fed via Test Probe and to the "Y" input of the oscilloscope

- Apply a 1 MHz standard frequency to the "X" input of the oscilloscope

- Use trimmer cap. C 1302 to align the resulting Lissajous figure so that it is stationary

- The error of the aligned frequency is less than 10^{-6} when the Lissajous figure does not rotate more than once per second.

5.3.6. D.C. loop holding circuit, BN 615/14

The printed circuit board "D.C. loop holding circuit" is useable both in the Generator LDS-3 and in the Receiver LDE-3.

The designation of the printed circuit board is: 615-N; 615-7012.--

Modification:

- Remove equipment chassis from case (for directions, see modification of crystal controlled time base)

- Pull-out the plug-in card which is located in the interior of the equipment chassis

- The printed circuit board should be pressed onto the two contact pins, and four screws should be used to fasten it down

- Re-assemble equipment (for directions see modification of crystal controlled time base)

Checking the functions:

Checking-out the functions is valid both for Generator and for Receiver.

Required test equipment: 1 each d.c. voltage supply 24 V
1 each d.c. voltmeter or digital voltmeter
1 each resistor 150 Ω, greater than 2 W.

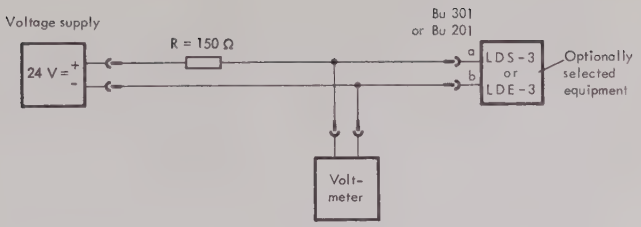


Fig. 5-8 Configuration for checking functions of the D.C. loop holding circuit

- In the indicated measurement configuration, test to determine if the voltmeter reading is between 9 and 13 V

Note: The voltage builds up slowly (approx. 45 s)

- Thereupon, reverse polarity at connector Bu 301 (LDE-3: Bu 201), and then repeat the measurement process.

5.3.7. Low-pass filter, BN 617/51

The low-pass filter is added to the Speaker Facility LDZ-3. The designation of the printed circuit board is: 617-C; 617-7002.--

Modification:

- Remove bottom cover from Speaker Facility
- Remove two jumper wires between points 33-27 and points 32-26. The jumper wires are located at the place where the low-pass filter is to be inserted.
- Low-pass filter is pressed onto the five contact pins and is fastened with four screws.
- Replace bottom cover

A check-out of functioning is not necessary.

5.4. Changing fuses

The a.c. power fuses of the Send Unit and the Receive Unit are accessible on the back panels of the Measuring Set. After unscrewing the cap of the fuse holder, the fuse element can be removed. The fuse for both Units is: T 2. 5 D (rated current 2.5 A, slow blow).

5.5. Shipping information

A safe, damage free shipment of the Measuring Set is only assured if correctly constructed packing is used.

If the original packing material has been lost, we recommend that the Measuring Set be packed as follows:

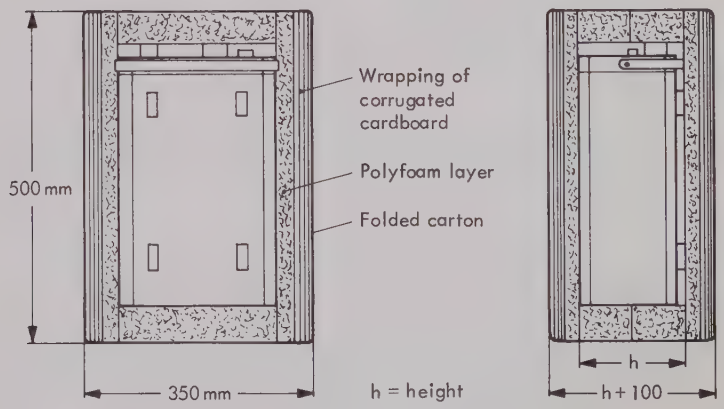
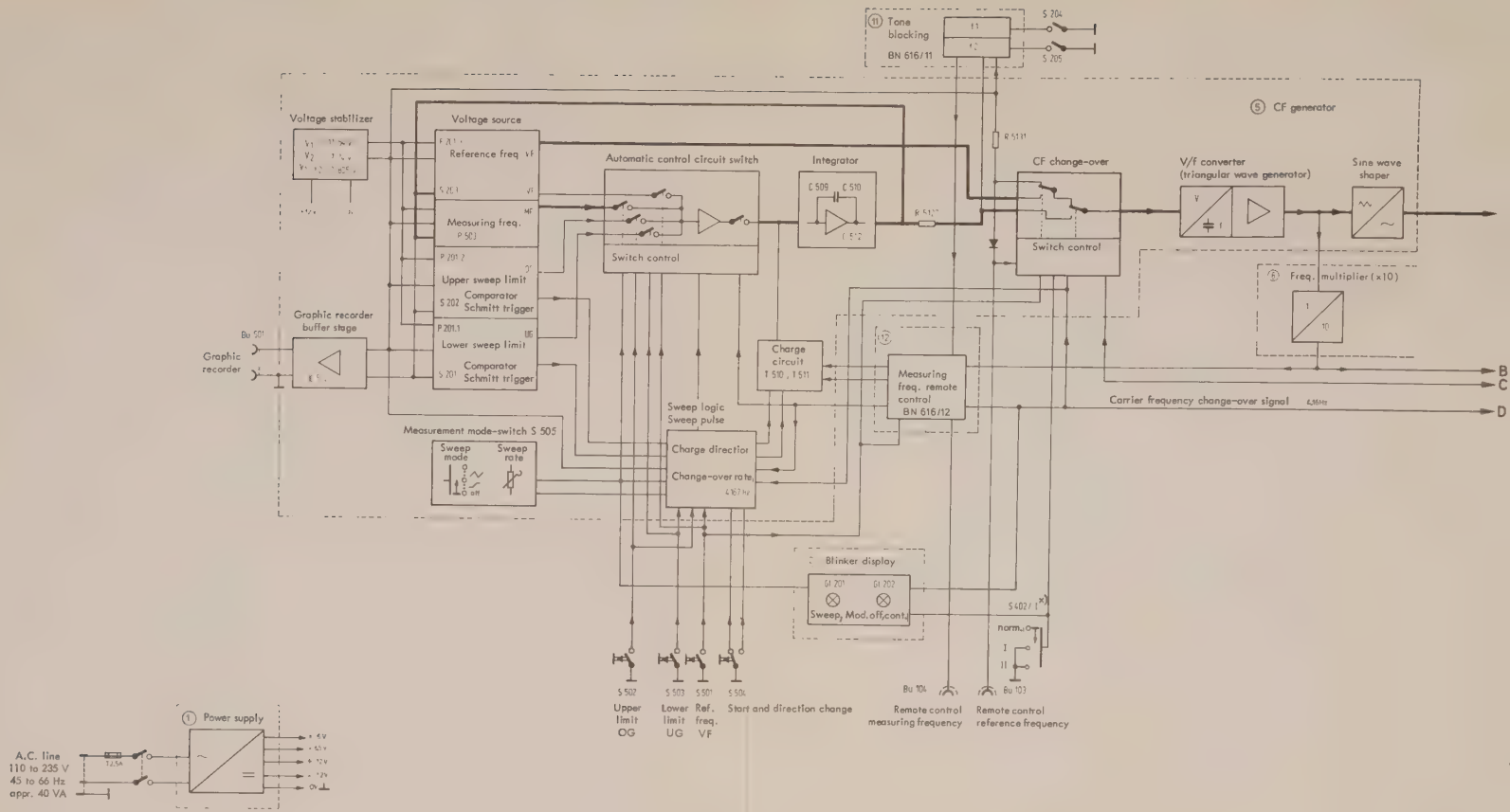
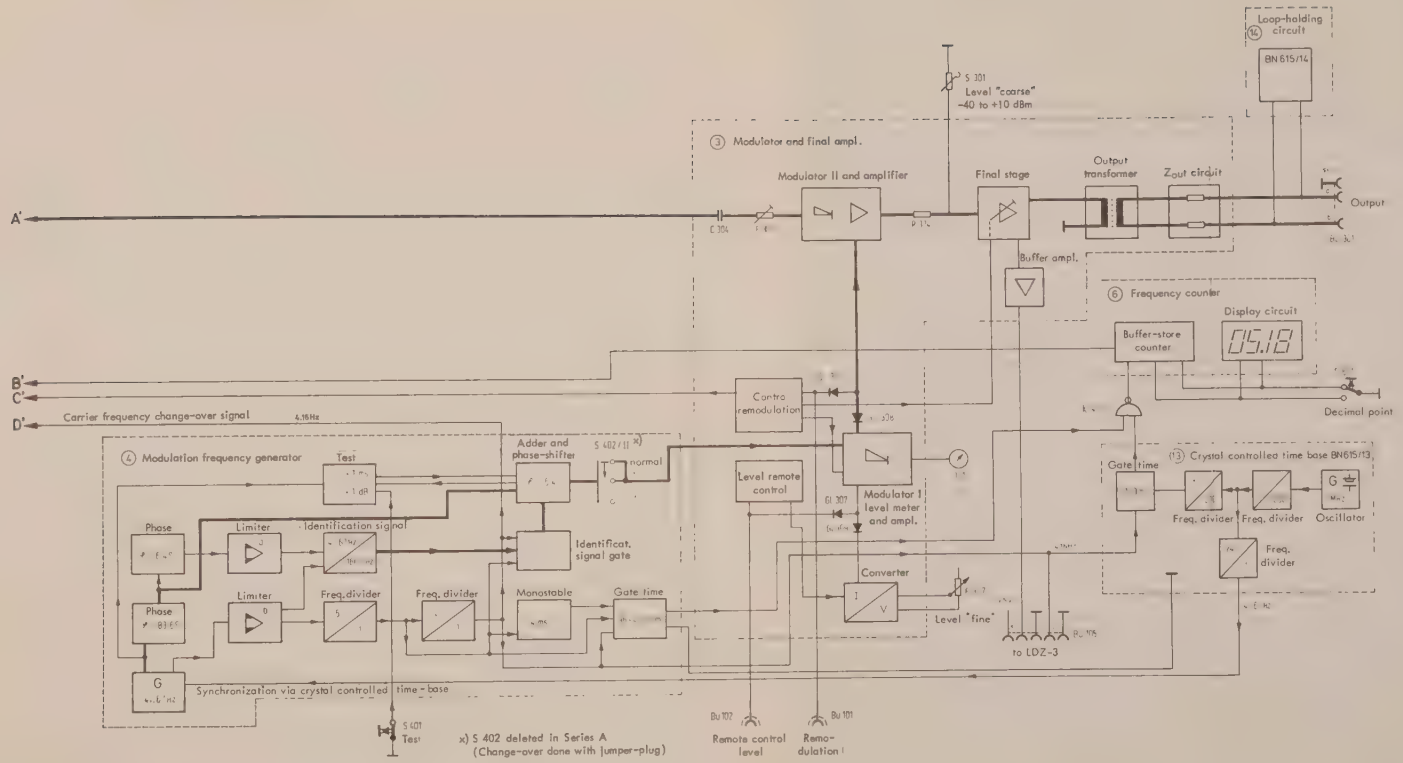


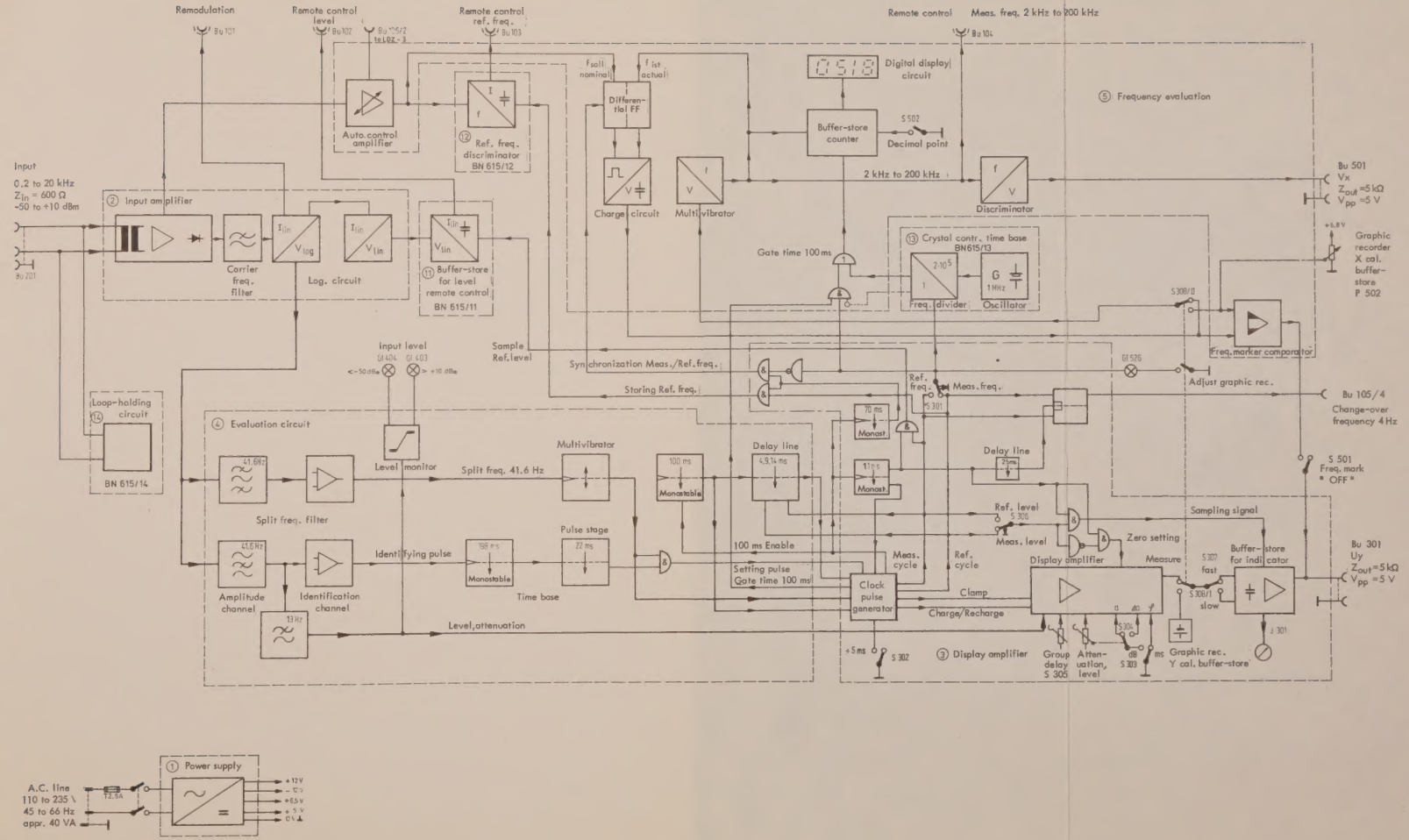
Fig. 5-9 Instructions for packing



Note: Circuits ⑪ ⑫ ⑬ ⑭ only are included if requested



LDS-3 BN 616
Block Diagram



Note: Circuits ⑪ ⑫ ⑬ ⑭ only are included if requested

LDE-3 BN 615
Block Diagram

MP MASTER
MA33538

Wandel u. Goltermann
7410 Reutlingen · Western Germany · Postbox 259 · Telex 0729833 wug d